OCTOBER, 1958
Vol. 12, No. 10

FT food technology

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IN SESSION, SUMMER 1958

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Babcock-Hart Award Address, 1958

The food industry in a changing world. Bernard L. Oser, Ph.D.

Food problems that the world's fast-growing population has thrust upon us, their relationship to the prospect of war or peace, various methods whereby world food production can and must be expanded, and the important part that creative science will play in rescuing the world from its dilemma are the topics considered. (See page 493).

Supplementation *Lysine in cereal products*

The role of lysine in cereal food products. Charles Feldberg and Carl P. Hetzel.

Supplementation of wheat-based foods with lysine will improve their protein quality and result in improved growth and tissue synthesis. The protein of wheat is naturally deficient in lysine. In addition, processing lowers the lysine content. Lysine supplementation has also improved the protein of rice, rye, and breakfast cereals. It may be possible to improve diets in underprivileged areas of the world by feeding lysine-supplemented cereals. Lysine-supplemented cereals may be recommended during periods of growth, pregnancy, lactation and stress, such as recuperation from surgery and illness, and for geriatric feeding. Any supplementation of cereal foods with the most limiting amino acid (addition of which will improve the natural amino acid pattern) should be considered sound nutritional practice. Thus, the protein of these foods will be fully utilized by the body for the function they should fulfill. They can only partially do so at present. (See page 496).

Preservative *Vitamin* K_5

Vitamin K_5 as a food preservative. H. Y. Yang, Wilbert F. Steele, R. W. Stein, R. F. Cain and Russell O. Sinnhuber.

Vitamin K_5 has been found effective in prolonging the storage life of a variety of food products. It was found to be effective in inhibiting growth of organisms obtained from moldy cheddar cheeese in an agar medium in concentration of 40 p.p.m. For organisms obtained from frankfurters, 60 p.p.m. was required. Low concentrations of vitamin K_5 (10 and 20 p.p.m.) were found to prolong storage life of crab meat, but the extreme discoloration observed would prevent commercial use. Development of a derivative of the vitamin might be a means of circumventing this problem. Heat stability of vitamin K_5 was demonstrated in agar streak plate tests and by the preserving action obtained in mushroom sauce after processing at 250°F. for one hour. Results would indicate that use can be made of vitamin K_5 for the preservation of food products not completely consumed immedintely after opening the container. It would have value in certain military feeding systems where refrigeration is not available. (See page 501).

Color measurement *Coffee roasts*

On the color of coffee. II. Angela C. Little, C. O. Chichester and Gordon Mackinney.

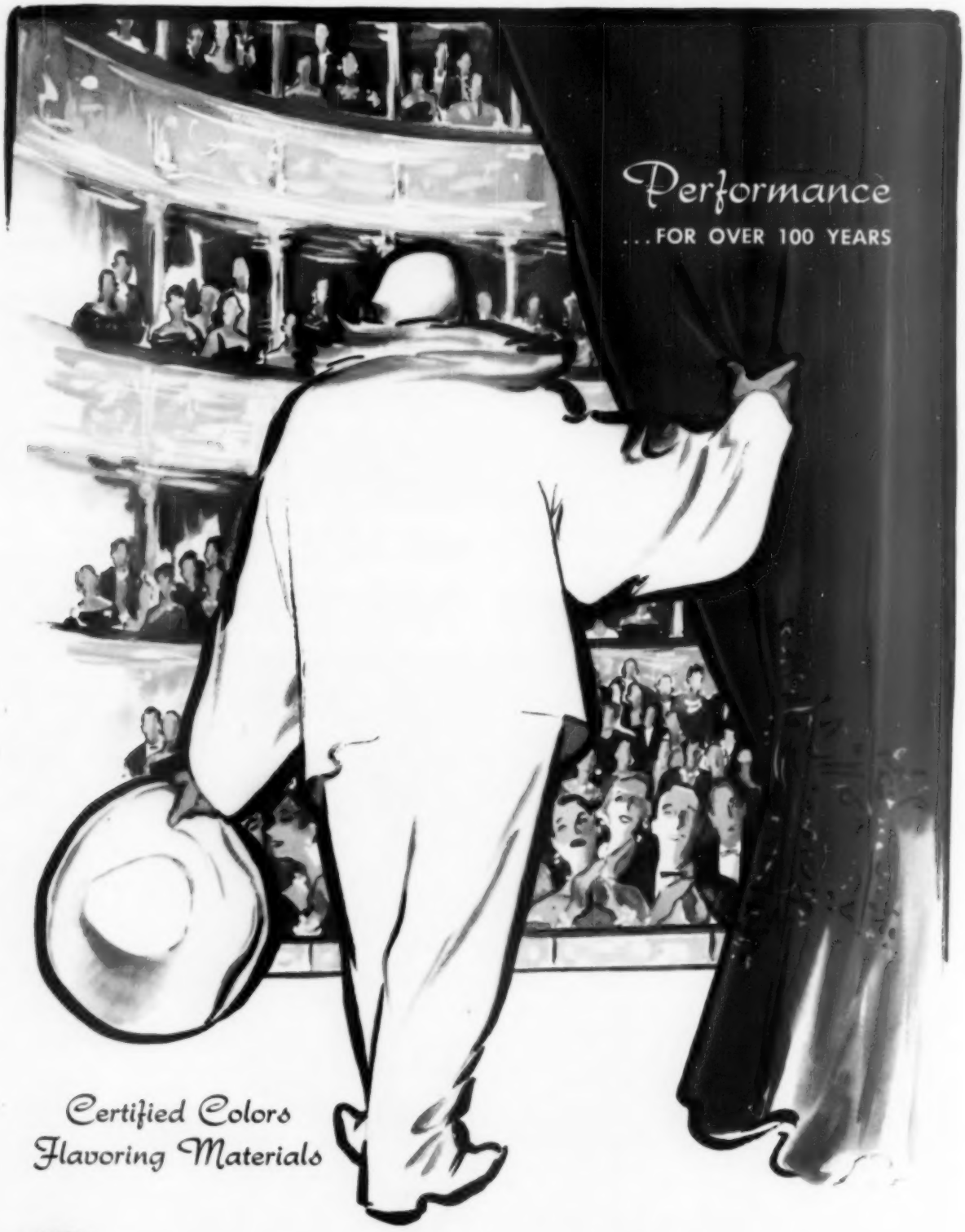
A modified Jabez-Burns laboratory roaster designed for constant input temperature has been described. A series of roasts under controlled conditions for six varieties of coffee indicate that rate of color development is relatively constant during the latter part of the roasting cycle for most varieties studied. Preliminary results on the measurement of the internal temperature of the bean during the roasting cycle are presented. Effect of load on development of color at constant input temperature and time of roast is discussed. Results indicate that a linear relation exists between area and Y value when the load is varied at constant input temperature. (See page 505).

Survey sampling method *Wine*

A sampling method for household surveys. II. Panel characteristics and their relation to usage of wine. F. Filipello, H. W. Berg, and A. D. Webb.

Employing a stratified, random sample of Sacramento households ($3,000–$10,000 yearly family income) willing to participate on a wine-tasting panel, a number of characteristics were noted in their relation to wine usage. General usage of wine increased with age of individual, implying that wine usage requires familiarization over an extended period of time. Usage of wine was affected by number of adults in the family; less usage was demonstrated by one-adult families. Socio-economic area and wine-consuming habits were not related. The educational level did not affect the usage of wine by men, but a greater proportion of regular users among women were college graduates. Both parental and extra-familial influences were shown to affect wine usage. There was a definite preference for 3% sugar against 1% Rosé test wine. This was shown by all categories of wine usage and increased with age group of the test panel. The preference was essentially the same for all socio-economic areas. (See page 508).

OCTOBER COVER. By courtesy of Wallace F. Janssen, Director, Public Information, Department of Health, Education, and Welfare, we are able to furnish a picture of a meeting between Food and Drug officials and industry representatives. The persons participating (who were not told who requested the picture, or where it would appear) are, left to right, John H. Jones, FDA, Paul M. Steffy, attorney, FDA, H. M. Hudson, reporter, Jesse E. Baskette, Nat'l Assoc. Margarine Manufacturers, Bernard L. Oser, Food and Drug Research Laboratories, Inc., Leonard D. Hardy, presiding officer, DHEW, G. F. Siemers, John Aeschlimann, Hoffmann-La Roche, Inc. and A. M. Gilbert and Joshua Levine, attorneys for Hoffmann-La Roche, Inc. and Best Foods, Inc. Subject of this hearing: food colors.



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New products *Derived from sweetpotatoes*

Preparation of new and improved products from Eastern (dry type) sweetpotatoes: chips, dice, julienne strips, and frozen French fries. Edward G. Kelley, Reba R. Baum, and Charles F. Woodward.

A number of varieties of Eastern grown (dry-fleshed) sweetpotatoes have been prepared in the form of chips, julienne strips and dice (cubes) by deep-fat frying, by methods previously described for other vegetables. These products were compared for crispness, toughness, color and flavor with chips made from moist or "yam" type varieties. French fried pieces were made under similar conditions of frying at varying times for use as frozen French fries. These were evaluated by taste panels after oven warming for periods similar to those used for frozen white potato French fries. Yields of finished product based on unpared and trimmed weights of many of the different varieties were calculated. Moisture values of fresh dug, storage cured and 3-month stored sweetpotatoes of at least two varieties were determined and the moisture contents were related to the oil absorption of the finished products. Carotene values were determined for several varieties, both fresh and after cooking, and the effect of storage for 3 months on the carotene content and the flavor were noted. A highly stabilized oil was used for this work so that no oil rancidity complicated the flavor determination. The sweetpotato products were well received by consumer type panels (both housewife and food manufacturer). As noted in previous studies on other vegetables (white potatoes excluded) there was a difference of opinion between panel members in regard to the preference for a toasted taste as compared with a slight "raw" taste. (See page 510).

Technology *Temperature control, popcorn*

Relation of sample size and temperature to volumetric expansion of popcorn. W. I. Thomas.

The proportioning pyrometer appeared to be more sensitive than the thermostat in controlling popper temperatures, especially when popping small samples. In addition, there was less scorching of the corn at high temperatures when heat was controlled with the pyrometer. Optimum temperature for maximum popping volume varies, depending upon the size of popping sample. As size of sample was increased, higher temperatures were required. Error of estitmating popping volume was least when the optimum temperature was used. Temperature of the popper was most critical in obtaining maximum volume with small size samples. Temperatures above or below optimum resulted in rapidly decreasing popping volume. (See page 514).

Color improvement *Removal of excess pigment*

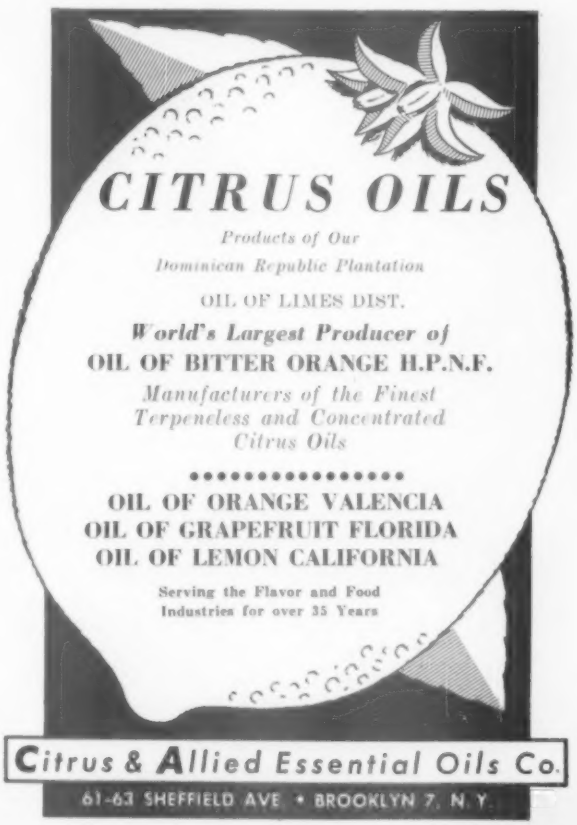
Removal of excessive anthocyanin pigment by enzyme. H. Y. Yang and Wilbert F. Steele.

Most food technologists are concerned with the preservation of natural pigments in food products during processing. There are actually some instances where the presence of natural pigment is excessive and its partial destruction is in order. A good example is blackberries, where anthocyanin pigment is present in excess. The excessive natural pigment not only causes concentrated products, such as jams and jelly, to look unattractive, but also renders glassed products, such as wine, unsalable. The excessive amount of pigment sticks to the inside wall of the wine bottle. Although the wine itself is in good condition, the customer shies away from the pigment-coated bottle. Partial removal of the pigment is, therefore, desirable and even necessary. It is done in this experiment by the use of the fungal enzyme, anthocyanase. Blackberries treated with 0.5% of the enzyme produce brighter, redder, more attractive jams and jelly. Blackberry wine so treated appears to be more stable, without pigment deposit or precipitation during storage. (See page 517).

Food colors *Carotenoids*

Industrial syntheses of carotenoids as useful food colors. O. Isler and G. F. Siemers.

Extension of the Isler synthesis of vitamin A has resulted in an economically commercial process for the manufacture of β-carotene and other carotenoids. These syntheses are not dependent on materials from animal, marine or plant sources which can vary markedly from year to year. Chemically produced carotenoids are of high purity and possess uniform color. Absorption spectra and other criteria demonstrate the chemically produced compounds to be identical with the same compounds isolated from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natural material. Tolerance studies indicate no health hazard to be associated with massive doses of β-carotene and other carotenoids. Chemically produced β-carotene and other carotenoids can serve the food industry as useful food colors. (See page 520).

Coloring fat-base foods with crystalline β-carotene. J. C. Bauernfeind, E. G. Smith, and R. H. Bunnell.

Commercial development of pure crystalline β-carotene as a food color and source of vitamin A prompted an investigation of its use in fat-base foods. Market forms of β-carotene are described and application of data presented on the incorporation of β-carotene in margarine, winter butter, shortening, lard, edible oils, egg yolk products, processed cheese and other fat-base foods products. (See page 527).

Coloring water-base foods with crystalline β-carotene. R. H. Bunnell, William Driscoll and J. C. Bauernfeind.

Crystalline β-carotene is highly acceptable for the coloring of water-base foods, as evidenced by appearance, flavor and stability performance. Juices, beverages, dairy products, baked goods, creamed foods, desserts, soups, etc. have been successfully colored with β-carotene. (See page 536).

Storage study *Spray-dried tomato powder*

Factors affecting storage stability of spray-dried tomato powder. Jackson C. Miers, Francis F. Wong, Jean G. Harris, and William C. Dietrich.

Data show that spray-dried tomato powder can be stored for 12 months at 100° F. when the powder is packed with a desiccant and canned in an inert atmosphere. Under such conditions, off-flavors, loss in ascorbic acid or sulfite, and change in soluble color were insignificant. High moisture levels, presence of O_2, and storage temperatures of 90° F. or higher were factors found to be detrimental to storage stability. Thus, if O_2 were eliminated from the can atmosphere by replacing with an inert gas, a moisture content of 1.8% (and perhaps higher) could be tolerated at 70° F. for long periods of time. At the higher temperatures of 90° and 100° F., it was necessary to reduce the moisture content with an in-package desiccant and to pack in an inert atmosphere. Reasonable storage stability in respect to flavor, soluble color, and ascorbic acid retention was obtained. (See page 542).

Storage methodology *Fresh vegetables*

Methods to extend storage of fresh vegetables aboard ships of U. S. Navy. H. T. Cook, C. S. Parsons, and L. P. McColloch.

Ration duration is a continuing problem in the Navy. New long-range naval craft have heightened the demands for longer shelf life. Methods of extending the storage life of fresh salad type vegetables on ships were studied. Such products have obvious nutritional advantages. Following are representative results: About 70% of the cabbage stored at 32° or 38°F. remained usable after 8 weeks. Quality was best at 32° F. Celery kept longer at 32° F. than at 38° or 45°. After 8 weeks, more celery was usable at 32° than at 38° F. None was edible after 6 weeks at 45°. Polyethylene bags or crate liners increased the storage life at 32° and 38° F. Lettuce trimmed of outside wrapper leaves before storage kept better for 6 weeks at 32° F. than at 38° or 45°. At 45° no usable lettuce remained after 6 weeks' storage. A larger percentage remained usable if trimmed of wrapper leaves before storage. Polyethylene bags or crate liners increased the storage life. In general, tests demonstrated that cabbage, celery, and lettuce retained better quality and are available longer at 32° F. than at the higher temperatures now used on ships. Tests showed tomatoes could be kept up to 6 weeks if loaded at a mature-green stage, kept at 55° to 65°F. while ripening, and then stored at 32° or 38° F. until used. Although the tomatoes would be available longer if ripened at 55°, they would have the best quality if ripened at 65° F. Ripened tomatoes kept better at 32° than at 38° F., but in either case they must be used immediately after storage. (See page 548).

Stability *Effect of curing ingredients, canned meat*

Effect of individual curing ingredients on shelf stability of canned comminuted meat. J. H. Silliker, R. A. Greenberg, and W. R. Schack.

Most shelf-stable canned cured meat products commercially available receive thermal processings far below that considered necessary to destroy resistant bacterial spores. It has been shown by several investigators that individual curing salts in concentrations consistent with legal and organoleptic limits do not prevent spore germination and outgrowth in canned meats. Which of the components of commercial canned cured meat contribute to its shelf stability was the concern of this investigation. It was found that, although viable spores could be recovered from the product after retorting, no spoilage occurred during incubation. The responsible factor was shown to be the combined effect of nitrite, salt, and thermal injury. When used individually, each element was unsuccessful in retarding spoilage. Nitrate enhanced commercial spoilage without preventing putrefaction. The nitrite-salt-heat effect was found to be dependent upon the low concentration of spores normally indigenous to meats. Artificial inoculation with large numbers of spores resulted in failure of the system. The investigators feel that these results offer an explanation for the excellent commercial experience with this type of product. (See page 551).

Grading *Apples*

Determination of relative value of apples and evaluation of experimental processing apple grades. Joseph M. Johnson, Anthony Lopez, and Charles B. Wood.

A method of determining price differentials for processing apples of different qualities and sizes is proposed. The method would accurately reflect relative values to the applesauce processors. It can be used in evaluating the effect that experimental grades for apples for processing have on grower returns from apples of different qualities. Apple value to applesauce processors is dependent upon the yields of prepared product for applesauce from a given

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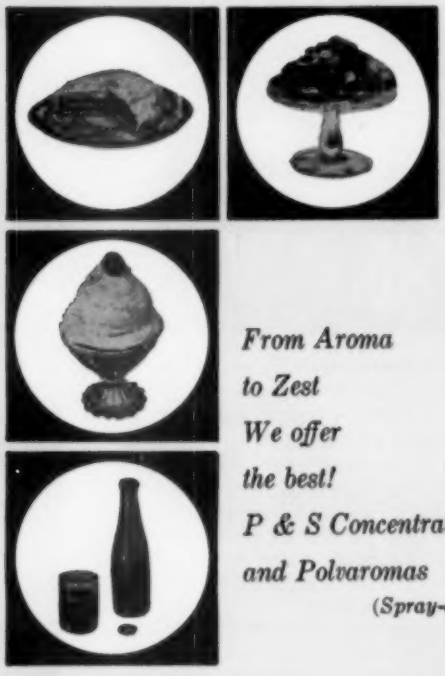

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volume of apples, values of recoverable waste products that can be used in making other products, and costs of processing and selling the applesauce exclusive of fresh apple cost. Relationships developed in this study, combined with data either available in the processing plant records or easily developed by a processing plant, can be used to derive price differentials for apples of different quality and size. These differentials will be in relation to the relative value of the apples to the processors. The proposed grades narrow the range of trim waste allowed in a given grade. This will tend to reward growers in proportion to the value of their apples to the processor. The proposed grades will also allow a reduction in the differential now assessed against table sorts. This would tend to encourage better packs of fresh fruit for the industry since a better outlet would be available for table sorts. (See page 554).

Packaging *Berries in display cases*

Maintaining freshness of berries using selected packaging materials and antifungal agents. John C. Ayres and Ervin L. Denisen.

Experiments were conducted to determine whether or not packaging materials and/or antifungal agents might be used to maintain freshness of strawberries, raspberries, and cranberries held in a refrigerated display case. Cellulose acetate, PHD-, LSAD-, and LSD-cellophane, polystyrene Q 641.4, polyethylene, Pliofilm, Visten, uncoated Mylar (50 ga.), Saran, Cryovac, and kraft paper bags were used as packaging materials. Berries were dipped in water solution containing 0, 5, 10, 20 or 25, 50, or 100 μg./ml. of one of the following antifungal agents: mycostatin, myprozine, rimocidin, ascosin, and candidin. In addition, field tests were made by spraying 10 or 20 p.p.m. of one of the antifungal agents on the fruit and allowing the berries to air-dry before picking; also the fungicide, captan, was sprayed on these fruits at a level of 2 parts per thousand. Packaged berries and unwrapped controls were observed during storage for discoloration, moisture-loss, accumulation of respiration gases, mushiness, and development of spoilage organisms; in addition, the packages were observed for fogging, permeability to gases, and for water-vapor transmission. Color and appearance of strawberries and raspberries packaged in cellulose acetate, polystyrene Q 641.4, and LSAD cellophane was better than in other materials; color and appearance of cranberries after storage for 2 months was best in Mylar. Water-vapor transmission rates for most of the films were unsatisfactory for optimum storage life; also, considerable package fogging occurred during refrigeration cycle breaks. Plastic containers were preferable to wooden boxes; the latter were less attractive and tended to contribute to mold growth. Berries dipped in water solutions of 10 or 20 μg./ml. of rimocidin or myprozine immediately prior to packaging had smaller microbial loads and somewhat longer storage life than did undipped or water-dipped controls. Results with antifungal sprays applied in the field immediately prior to harvest were less beneficial. (See page 562).

Food procurement, distribution *Military, U. S.*

The Military Subsistence Supply Agency. Colonel Charles A. Shaunesey, Jr.

This paper presents the organization and activities of the Military Subsistence Supply Agency (MSSA). The Agency, formerly the Quartermaster Market Center System, is one of the single-manager central supply agencies established by the Department of Defense in 1956. It continues to purchase, at wholesale level, all perishable and non-perishable foods supplied to the Army, Navy, Air Force and Marine Corps. Now, under the unified Defense Department program, it also warehouses, distributes and directs the inspection of military subsistence supplied to the Armed Services. (See page 568).

New device *Sample rotator for color measurement*

A sample rotator for the Hunter Color and Color-Difference Meter. H. C. Lukens and F. G. Creese.

Design and operation of an attachment for rotating a sample of a food product during color measurement with the Hunter Color and Color-Difference Meter are discussed. The device features rapidity, convenience, and safety of operation as well as reproducibility of positioning the sample relative to the instrument. Readings obtained on the Hunter scales agree closely with averages of those for quadrants of the sample while not rotating. This is illustrated by data on several food products. The rotator provides a rapid method for obtaining the average color of heterogeneous samples. (See page 570).

Food Additives

A "Recap" of the Annual Meeting Panel Discussion in Chicago

FRANK L. GUNDERSON
Moderator

FOOD ADDITIVES are functionally indispensable to preserve and make attractive the wide variety and availability of our foods, and will become more numerous and vital to world nutrition as the population increases. Passage of a new regulatory Amendment by Congress this year was still doubtful at the time of this Meeting (May 28).* The facts and the fallacies of safety evaluation procedures were laid before a large and attentive audience. Responsibilities which the above situation places on the analytical departments in food and chemical industries are enormous.

The full hour for questions, answers and discussion following an 80-minute panel presentation seemed to suit well the interests of the large audience.

CONSUMER ACCEPTANCE A MEASURE OF FUNCTIONAL USEFULNESS

Dr. B. F. Daubert emphasized that consumer acceptance as measured by methods well known to food processors can best determine the functional usefulness of food additives. He gave illustrations wherein the food processor is completely dependent on additives (1) either in the processing stages or (2) to impart certain characteristics to the food for the benefit of the consumer or (3) to help prolong and stabilize the preservation of the food in order that our wide variety of grocery items not become unnecessarily expensive.

Dr. Harold Schultz also addressing himself to the usefulness, the utility, or functionality (as it is often called), of food additives summarized the situation well by stating that "some are used to color foods, others to bleach them; some add flavor to food, others remove flavors; some make foods firmer, others soften them; some keep foods dry, others keep them moist; some thicken foods, others keep them from thickening; some produce foams, others prevent them, some make the foods acid, others make them alkaline, still others help suspend particles; some are added to increase the mineral ions, others to remove them; some are oxidizing agents, others are reducing agents; some hasten chemical changes, others retard them."

STATUS OF LEGISLATION AS OF MAY 1958*

Dr. B. L. Oser summarized briefly the legislative status. Hearings on proposed chemical additives legislation were concluded April 15, but at the time of the IFT Meeting neither the Subcommittee on Health and

* **Note:** On the eve of going to press it becomes possible to report the passage of **Food Additives Amendment of 1958, Public Law 85-929, September 6, 1958.** Copies of this law are available from the Superintendent of Documents, Washington 25, D. C., at 5c each. F. L.G.

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Science nor its "full" committee, the House Interstate and Foreign Commerce Committee, had yet "reported out" a specific recommendation to the floor of the House. Simple legislation to require pre-testing for safety and the reporting of intention to distribute food containing such additive would go a long way. Most of the bills are complicated and include controversial features on the utility of additives, the grandfather clause, the ad hoc scientific advisory committee, and the judicial recourse procedure. It will be a pity, if after these 8 or 9 years of substantial discussions, this Congress is unable to enact an Amendment accomplishing those objectives on which there is little if any controversy. Total perfection and full attainment are not expected. Concurrently, a bill, HR9521, by Congressman Haley to eliminate the necessity of labeling the specific post-harvest fungicide, on fruits and vegetables, has been "reported out" favorably by the Subcommittee by the narrow margin of 4 to 3. An additional compromise bill also is possible.

Dr. Henry F. Smyth, Jr., pharmacologist, gave a stimulating report on the "Safety Evaluation Procedures and Interpretations" used to appraise safety of food additives. His introspective scrutiny upon procedures suggests further improvements. (The report by Dr. Smyth was published in full in the August issue of FOOD TECHNOLOGY).

ANALYTICAL PROBLEMS ARE FORMIDABLE

The analytical problems posed by food additives use and legislation are a formidable challenge to analytical chemists, said Dr. J. F. Mahoney. We shall need to develop more sensitive and accurate methods not only for the additives themselves, but also for separating the additives from the other components of the foods. These methods will be essential for use by food processors, by additives producers, and by regulatory officials.

ANTIBIOTICS

Dr. Wilbur Miller commented on the use of antibiotics in food stabilization and reported it is proceeding well under FDA and Agricultural Marketing Service regulations with respect to poultry. While the Canadian Government has approved it for fish as well as for poultry, the use of antibiotics for treatment of fish in the U.S.A. is still uncertain, at least as to the date when that preservative practice may be started.

Dr. F. N. Peters spoke about the work of the Food Protection Committee and the Food and Nutrition Board of the NRC. He called attention to the projected one-day symposium on food packaging materials as viewed from the food additives standpoint to be held in Washington, D. C. in December 1958.

Questions and comments from the audience indicated a keen understanding of the usefulness as well as the complexities of problems inherent in the food additive subject.

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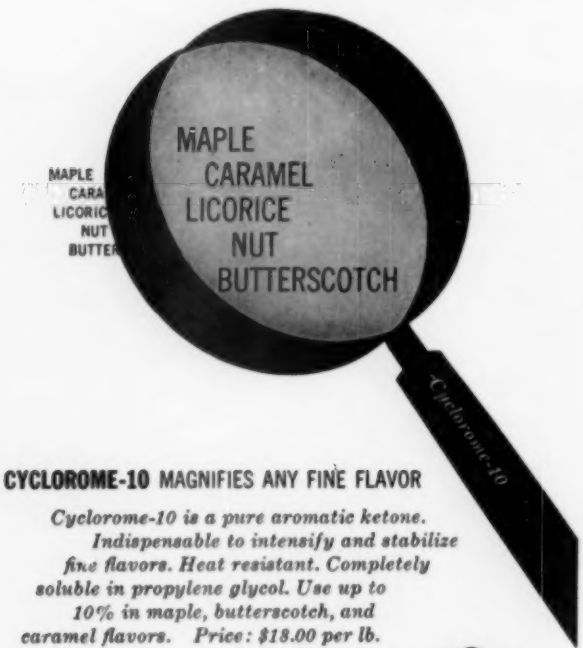
Fifteen Sessions to Comprise Nineteenth Annual Meeting Technical Program in Philadelphia, May 17 through May 21, 1959

Session Chairmen Appointed

At a meeting of the Program Committee, August 7, 1958, the technical sessions for the 1959 meeting of IFT were finalized and the "ground rules" for papers laid down. Morning sessions will run from 9 a.m. until noon; afternoon sessions, from 2:30 to 5 p.m. The Committee decided that three papers per hour would permit a session chairman to preside over a good meeting and give opportunity for questions. Maximum time allotted a session paper is 20 minutes. Invited papers are limited to 30 minutes.

DEADLINES

In order to meet the schedule the titles and authors of papers must be reported to the session chairmen by December 1, 1958. Abstracts of papers must be sent in to session chairmen by January 1, 1959.



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SESSIONS, SESSION CHAIRMEN, AND THEIR ADDRESSES

General Research. Dr. H. H. Mottern, National Dairy Products Corp., Glenview, Illinois, will lead the session devoted to general research papers. Dr. Mottern directs research at the Glenview laboratories of the Corporation.

Cereal and Baked Products. Chairman of this session is Dr. William F. Geddes, Professor and Chief of the Division of Agricultural Biochemistry, University of Minnesota, St. Paul, Minnesota. Dr. Geddes has long been associated with *Cereal Chemistry*, the professional journal of the American Association of Cereal Chemists and was chosen Appert Award medalist for 1958.

W. Geddes B. A. Wright

Meat and Poultry. Mr. Bertrand A. Wright, Quality Control and Food Research Division, Armour & Co., Union Stock Yards, Chicago 9, Illinois, will chairman the session on meat and poultry research and development. Mr. Wright has been active in this area of food science and technology and in IFT affairs for many years.

Radiation and Preservation. This session will be led by Dr. F. P. Mehrlich, recently appointed Director of the Quartermaster Food and Container Institute for the Armed Forces, the Chicago laboratory of the Quartermaster Research and Engineering Command, Natick, Massachusetts.

Frozen Foods. Dr. J. G. Woodroof, Chairman, Division of Food Processing, University of Georgia, and

J. G. Woodroof F. P. Mehrlich

a veteran in frozen foods research, will lead this session. His address is the Georgia Experiment Station, Experiment, Georgia.

Heat Processing. Dr. C. Olin Ball, Department of Food Science, Rutgers University, New Brunswick, New Jersey, will chairman the session on heat processing research. Dr. Ball and his co-author, F. C. W. Olson, published in 1957 *Sterilization In Food Technology* (McGraw-Hill).

Fruit Products. Dr. Claude H. Hills of the Eastern Regional Research Laboratory, Eastern Utilization Research and Development Division, USDA, Philadelphia, Pennsylvania, will lead this session. Dr. Hills has been identified with investigations on fruit products for many years and has many contributions to the journals to his credit.

Fish. Chairman of the session on fish and fisheries products is Mr. Clifford F. Evers, co-author with Donald K. Tressler of the *Freezing Preservation of Foods* (Avi) published in 1957. His address is the International Minerals and Chemicals Corp., 20 North Wacker Drive, Chicago, Illinois.

C. F. Evers J. H. Nair

Production. Chairman of this session is Mr. John H. Nair, Consultant, 9 Dunnder Drive, Summit, New Jersey. Mr. Nair has been active in the professional

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W. S. Young

societies throughout his career. He was president of the American Institute of Chemists during 1957.

Automatic Process Control. Mr. Wendell S. Young, The Foxboro Company, Foxboro, Massachusetts, is the chairman of the session on automatic process control. This subject has always attracted great interest when inincluded in IFT annual meetings. Mr. Young is manager of the Food Industries Division of the Foxboro Company.

Food Additives. Chairman of this session is Dr. John F. Mahoney, Merck and Company, Inc., Rahway, New Jersey. Dr. Mahoney was one of the panelists on last year's session on food additives and has actively followed the course of the law in this field over many years.

J. F. Mahoney

F. Gunderson

Definitions of Standards of Identity of Foods. Dr. Frank Gunderson, Technical Consultant, 1003 Dupont Circle Building, Washington, D. C., will lead this session. Dr. Gunderson has had wide experience in the fields of food science and technology. For the past several years he has vigorously promoted the cause of sound legislation with regard to food and food manufacture.

A. P. Sidwell

Quality control. This session is under the chairmanship of Dr. Arthur P. Sidwell of the Quality Evaluation Section, Biological Sciences Branch, Marketing Research Division, USDA, Beltsville, Maryland. Dr. Sidwell has

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Thanks to the endless variety of quick-and-easy-to-use prepared food and dessert mixes now being marketed, today's housewife has more hours to enjoy outside of the kitchen than ever before – hours she can now put to more useful pursuits and purposes. As competition for her patronage of these time-saving products increases, she becomes more selective in her choice. By trial and error, she discovers the brand that best satisfies her family's taste, and sooner or later it is that brand with the best flavor that finds its place on her regular shopping list . . . When developing the flavoring or seasoning formulation for your new food, beverage, confectionery or dessert offerings, remember this: NOTHING SELLS LIKE FLAVOR! So, when you choose flavor, choose the *best* – use FRITZSCHE'S . . . *A FIRST NAME IN FLAVORS SINCE 1871.*

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Here's what Flo-Sweet

Today, with more and more food manufacturers looking for new ways to cut costs and improve quality, "Research & Development" activities are helping many companies set new records. Here is a status report on a number of Flo-Sweet R&D projects which may hold valuable information for you.

When you hear the words "research and development" you are likely to think of a Hollywood science fiction setting: laboratories crowded with gleaming glassware, white-smocked technicians peering earnestly into test tubes and microscopes, sensitive fingers manipulating the delicate controls of complicated instruments. Places like this really do exist; and one of them is the well equipped and competently staffed Flo-Sweet laboratory at our headquarters and refinery in Yonkers.

Why do we maintain such a comprehensive laboratory?

The answer is simple: to give *you*, the food manufacturer, new and better sugars to help you improve your products so that you can keep ahead of your competition.

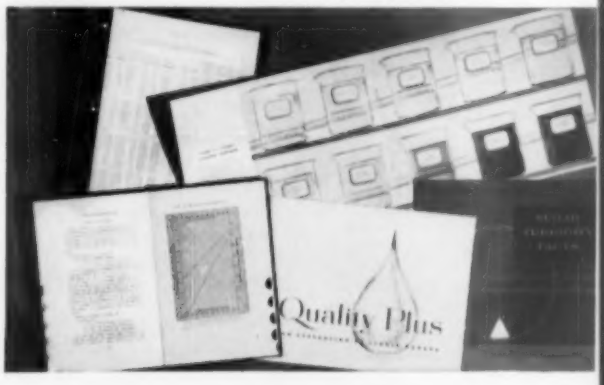
New Ideas Galore

From the very conception of the liquid sugar idea, which Refined Syrups pioneered, down to today's exciting developments in blends and Multi-Sugars, Flo-Sweet research and development have brought you a host of advances that have helped you cut your costs, increase your production, and improve your quality. For example:

Flo-Sweet was first to deliver liquid sugar on a bulk commercial basis, first to establish complete engineering service in design and installation of liquid sugar systems, first to formulate liquid sugars tailored to customer specifications. Flo-Sweet was first to develop food product quality control through use of liquid sugar, first to devise means of preventing surface dilution of liquid sugar in storage, first to develop effective means of controlling the temperature of liquid sugar going into production.

More recently, Flo-Sweet was first to come to grips with the problem of measuring turbidity, evaluating it, and controlling it to establish, in effect, new high standards of purity for the entire beverage industry. Flo-Sweet was first to conduct basic research into colors of sugar solutions and their correlations with refinery efficiency and resulting sugar purity. And Flo-Sweet was first in the entire sugar industry to publish an authoritative handbook on liquid sugar—

Flo-Sweet research has helped customers solve many problems. Factual reports, technical papers, illustrated brochures, and an authoritative handbook have been published to disseminate information as widely as possible.



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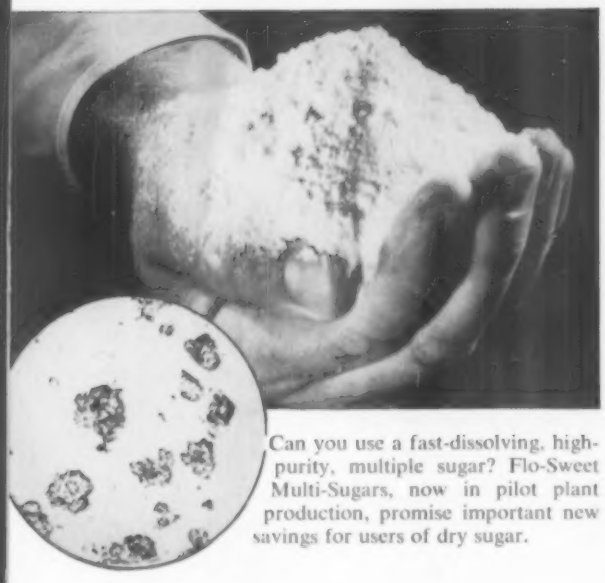

Can you use a fast-dissolving, high-purity, multiple sugar? Flo-Sweet Multi-Sugars, now in pilot plant production, promise important new savings for users of dry sugar.

making freely available, to customers and competitors alike, the factual results of thoroughgoing research painstakingly carried on through the years.

What Next?

In recent months, our customers in the metropolitan New York area have been enjoying the advantages of Flo-Sweet Sucrodex—a whole new family of sucrose-dextrose liquid sugars formulated to meet individual requirements. These Sucrodex sugars are Comogenized at our refinery to provide the utmost in uniformity. The enthusiastic reception that Sucrodex has received obviously suggests enlargement of the areas in which it is available.

As an adjunct to Sucrodex, plans are well under way for a line of companion products combining invert and dextrose sugars. We have kept this project "under wraps" for many months; and our research is now far enough along so that we can promise you rapid progress on this new group of sugars.

Possibly our most exciting research project hinges around our concept of Multi-Sugars—dry sugars consisting of different sugars interlocked in inseparable crystalline form. The Multi-Sugars so far developed are light, almost fluffy; are very fast dissolving; form clear, colorless solutions; make brilliant, white icings; and offer a number of other very attractive features. You will be hearing much more about Flo-Sweet Multi-Sugars!

Where You Fit In

All Flo-Sweet research, you will note, is directed toward helping *you*, the food product manufacturer. This research, our advertising, our own sales and sales engineering efforts are all directed toward *you*. This is to keep you well informed, to help you take full advantage of the many services we provide, to help you boost your own product quality and value to the utmost.

For the Flo-Sweet R&D laboratories are staffed not only with sugar experts, but with specialists in the many food industries as well. We are primarily food technologists – equipped and organized to handle *your* problems in food processing. In R&D as well as in production and sales, we have long followed the policy of serving industrial sugar users exclusively. In a word, this means serving *you*.

Frederic A. Davidson

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President

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Adding vitamin A to your product is about as simple as adding salt. We put it up for you in pre-measured cans that you just pour in—one can to one batch of product. No fuss or bother.

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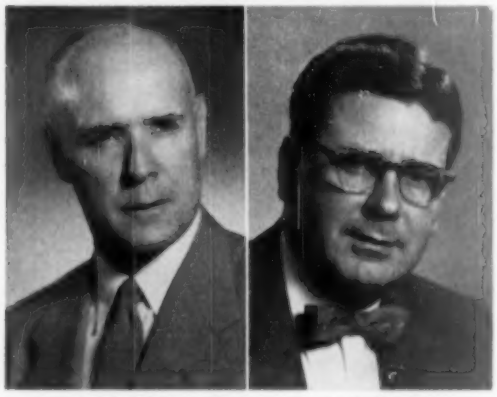
been identified with college, industry, and Government research, all in relation to food. He is a frequent contributor to the scientific journals.

Packaging and Pressurized Containers. Mr. Eugene J. Kane of Thomas J. Lipton, Inc., 1500 Hudson Street, Hoboken, New Jersey, will lead this session. Mr. Kane directs packaging research for Lipton's.



E. J. Kane I. J. Pflug

Food Engineering. Dr. I. J. Pflug, Associate Professor of Food Technology-Agricultural Engineering, Department of Agricultural Engineering, Michigan State University, East Lansing, Michigan, will lead this session. Dr. Pflug is an Associate Editor of FOOD TECHNOLOGY.

IFT News

Awards

Call for Nominations

Nicholas Appert Award

The Nicholas Appert Medal and an honorarium of $1000, is awarded annually to a person for "preeminence in and contributions to the field of Food Technology."

Nominations for the Award may be made by any member of the Institute of Food Technologists. They must be in letter form giving a biographical sketch of the nominee and indicate the contributions that qualify him or her for the Award. Nominating letters shall be limited to two, single-spaced, typewritten sheets.

If you know someone who, in your opinion, is eligible for this Award, do not delay; send in your nomination today! Nominations must be submitted before November 1, 1958.

Send Nominations to: Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

What can distilled monoglycerides do for these foods?

When you take a reaction mixture of mono- and diglycerides and use molecular distillation to produce a monoglyceride emulsifier of exceptional purity, some wonderful things can happen. For example:

In dessert toppings—with *Myverol® Distilled Monoglycerides* you can make ordinary homogenized milk whip up into a lovely whipped product with good texture and overrun. With vegetable-oil-based toppings, you can use *Myverol* to give you the high overrun and low whipping time you seek.

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Babcock-Hart Award

The Babcock-Hart Award, consists of $1,000, donated by The Nutrition Foundation and an engrossed plaque furnished by the Institute of Food Technologists. This Award is made annually to an individual "who has distinguished himself or herself by contributions to Food Technology which have resulted in improved public health through some aspect of nutrition or more nutritious food."

Nominations for the Award may be made by any member of the Institute. They must be in letter form giving a biographical sketch and listing the achievements of the individual recommended. Letters of nomination must be not more than two, single-spaced, typewritten sheets.

If you have someone in mind who, in your opinion, is eligible for this Award, do not delay; send in your nomination now! The deadline for nominations is December 1, 1958.

Send Nominations To:

Institute of Food Technologists
176 West Adams Street
Chicago 3, Illinois

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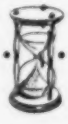

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Food Technology Industrial Achievement Award

The Institute of Food Technologists announces the establishment of a *Food Technology Industrial Achievement Award*. The Award will include the following:

To the Company or Institution concerned, a Bronze Plaque suitable for mounting.

To the individual(s) judged to have made major contributions to the achievement, either through basic research or development, public recognition at the time of presentation, and an engrossed plaque.

The purpose of this award is to honor an outstanding food process and/or product which represents a significant advance in the application of Food Technology to food production. It must be one which has been successfully applied in actual commercial operation for not less than 6 months or more than 4 years prior to September 15, 1958.

Any member of the Institute of Food Technologists may make nominations for the award. Each nomination must be in letter form and include the following:

a. Name of Company or Institution.
b. Name of Product and/or Process.
c. Description of Product or Process.
d. Statement of reason for considering this a meritorious achievement.
e. Statement listing individuals chiefly responsible for the achievement and their individual contributions.
f. Statement indicating the time and extent of commercial utilization.

Nominations must not exceed three, single-spaced, typewritten pages. Nominations should be sent to:

Institute of Food Technologists
176 West Adams Street
Chicago 3, Illinois

To be considered nominations must be postmarked not later than December 10, 1958.

Here are Some Ways that National Headquarters Can Serve You

If you are an employer

and are seeking Food Technologists: Just have your Personnel Manager send the job description(s) to the Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3. The Secretary will send you in return the names of candidates for jobs together with resumés of their qualifications.

If you are a candidate for a job

and looking for a position or a change of location: Write the Executive Secretary, IFT, 176 West Adams Street, Chicago 3, Illinois for a resumé form. Fill in

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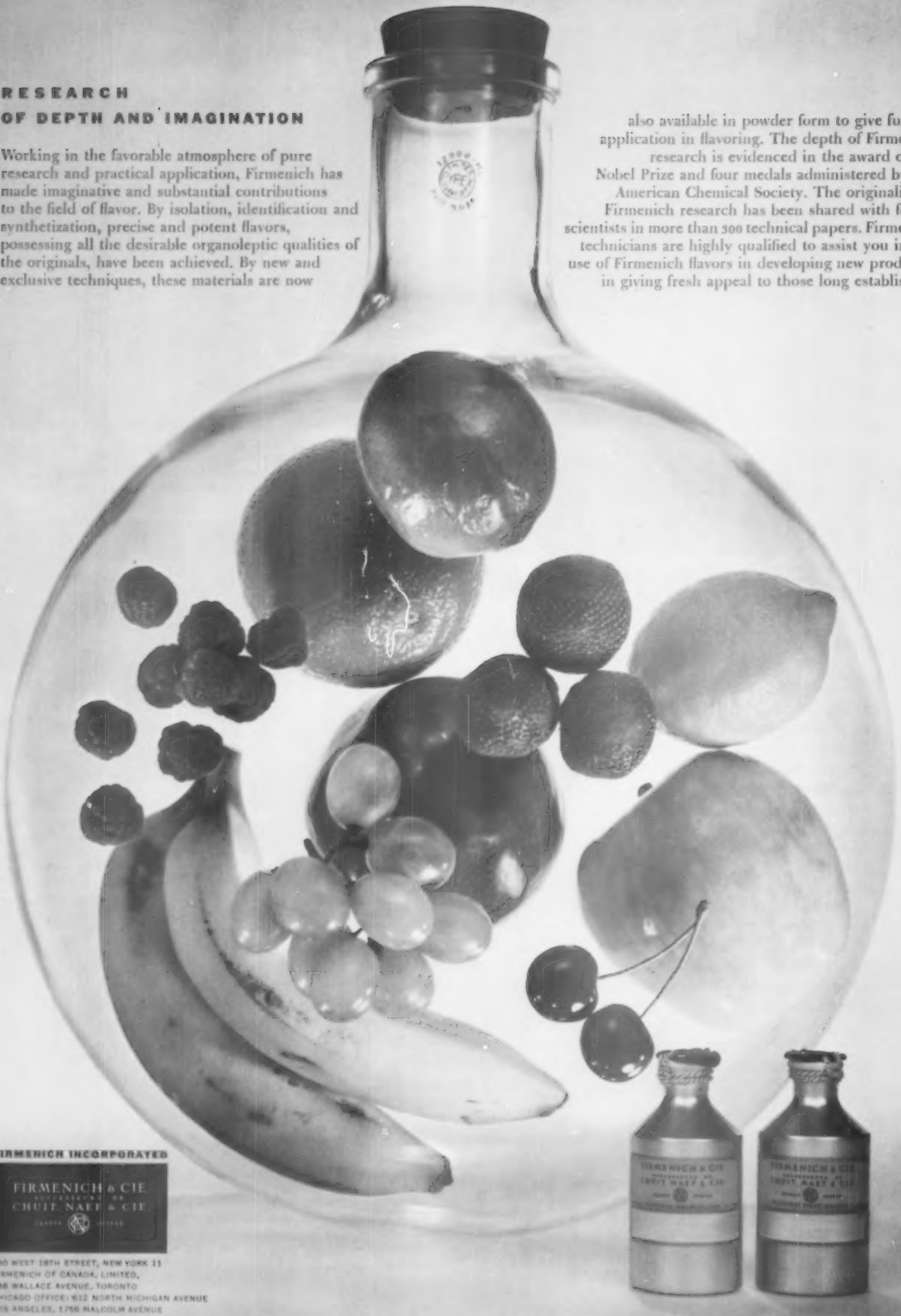

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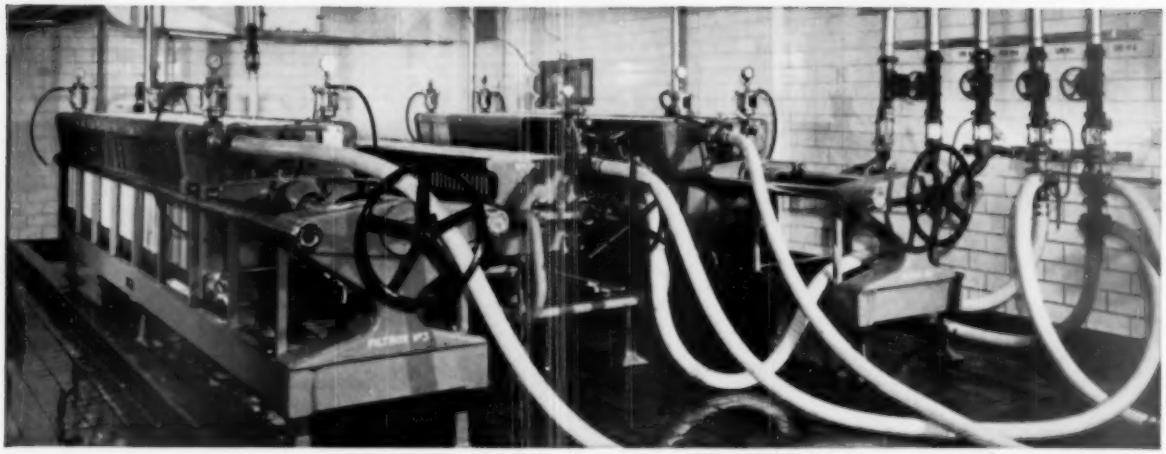
at MILLER Brewing Company . . .



These third-stage filters help Miller Brewing Company obtain the famous golden brew of Miller High Life Beer. Foxboro Magnetic Flow Meters are used to control flow of beer to filters.

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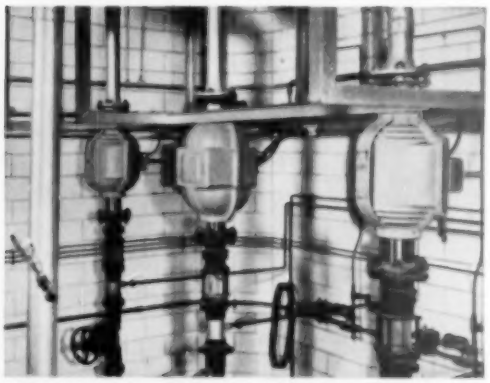
without disassembly

Foxboro Magnetic Flow Meters installed at Miller Brewing Company are cleaned just like a length of pipe. Operators send chemical cleaners and ball brushes right through the lines — meters and all — *without* removal or disassembly.

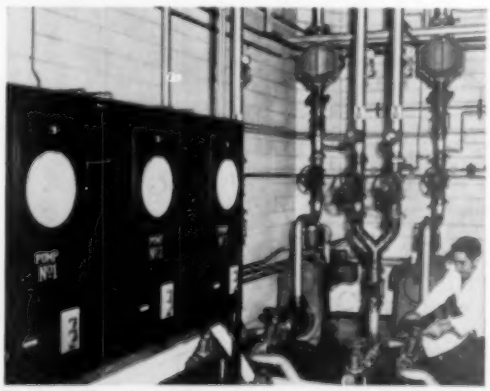
This clean-in-place procedure is made possible because the Magnetic Flow Meter has no more flow restriction than an equivalent length of pipe. Measurement is made by two flush-mounted electrodes . . . so, there are no bacteria-catching orifice plates, pressure taps, or pipe line crevices. Any cleaning device can be sent right through the meter as installed. No need to take it apart or remove it from the line.

But Foxboro Magnetic Flow Meters are more than just a boon to sanitary flow measurement. They provide the brewers of Miller High Life beer with automatic, precise control of flow to filters. Presetting of flow rates gives more efficient filtration as well as more effective coordination between brewing operations.

With liquids as light as beer, or with viscous liquids and slurries, the Foxboro Magnetic Flow Meter provides accurate, trouble-free flow measurement. Get the complete story in Bulletin 20-14B. **The Foxboro Company, 3510 Norfolk St., Foxboro, Mass.**



Miller cleans these Magnetic Flow Meters in place—without taking them apart or removing them from the line. Downtime for cleaning is reduced considerably. The meters have no flow restrictions — are installed just like a length of pipe.



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and need assistance in setting up your itinerary: Get in touch with the Secretary's Office (telephone, Andover 3-6268, Chicago) and they will arrange with a reliable, experienced agency to handle air, steamship, or rail tickets, recommend hotels and make reservations. There is no fee. You pay only the regular transportation and hotel rates. This takes most of the bothersome details of travel off your shoulders.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1958 October 22–24	Fifth National Vacuum Symposium, American Vacuum Society, Sir Francis Drake Hotel, San Francisco, California
1958 December 26–31	American Association for the Advancement of Science, Washington, D. C.
1959 March 4–6	Southeastern Conference on Better Foods, The Georgia Center for Continuing Education, University of Georgia, Athens, Georgia
1959 May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadephia, Pennsylvania**
1960 May 15–19	**Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California**
1961 May 7–11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962 June 17–20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11406 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

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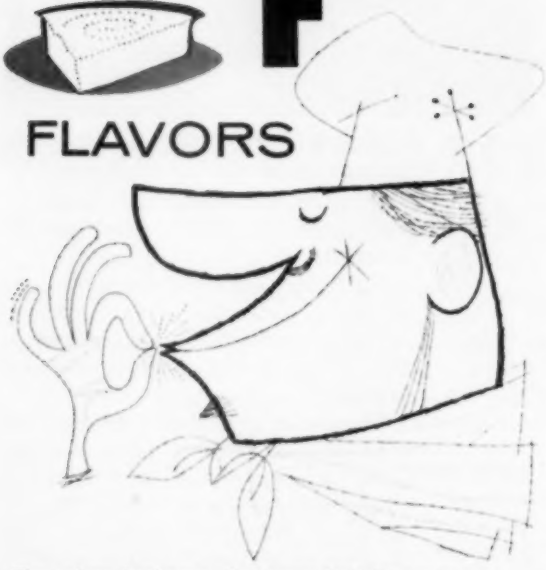

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Literature

BOOKS

BIBLIOGRAPHY OF FOOD. E. Alan Baker and D. J. Foskett. Academic Press, Inc., New York, and Butterworth's Scientific Publications, London, 1958.

This bibliography is not only a book; it is also an important event in the history of publishing as it relates to food science and technology. The secondary title "A Select International Bibliography of Nutrition, Food and Beverage Technology and Distribution, 1936–1956" succinctly describes the scope of the work. The table of contents provides the details of coverage: The literature on world food supplies, distribution, marketing, and retailing, prices and statistics, food control and rationing is covered in the first 14 pages. Nutrition literature occupies 44 pages. Food preservation, storage, packaging, and transport take up another 44 pages. The literature on food analysis, food hygiene and food poisoning, food legislation and inspection is contained in 16 pages. The bibliography of products—starting with milk and milk products and including thereafter the various divisions of plant, animal, and beverage subject matter—runs from page 118 to 284. There is an author and subject index.

The usefulness of the *Bibliography of Food* for graduate study needs no elaboration except to say that new vistas on foreign literature will be available to graduate students and others not as familiar as they should be with these rich resources. Bibliographic resources of the U.S.S.R. are revealed and there are even a few entries for Communist China. The increase in German food publications during post war years is of interest.

The organization of the book is based on the plan of listing the bibliographies and abstract journals first, then the periodicals, and following the periodicals are general (usually non-serial) publications, and the professional organizations that serve a given field. The Institute of Food Technologists, by the way, is well represented, both as to authorship and sponsored publications.

Those who may be disappointed not to find a particular entry are referred to the introduction of *The Bibliography of Food*. The authors have sought to furnish a representative selection and have excluded from the plan, "with reluctance," they inform us, the literature on food production. Within the boundaries they have set, E. Alan Baker and D. J. Foskett, the authors, have achieved a valuable and notably accurate bibliography—and one that will be well-thumbed by all who are seriously engaged in the vast field of food research and technology.

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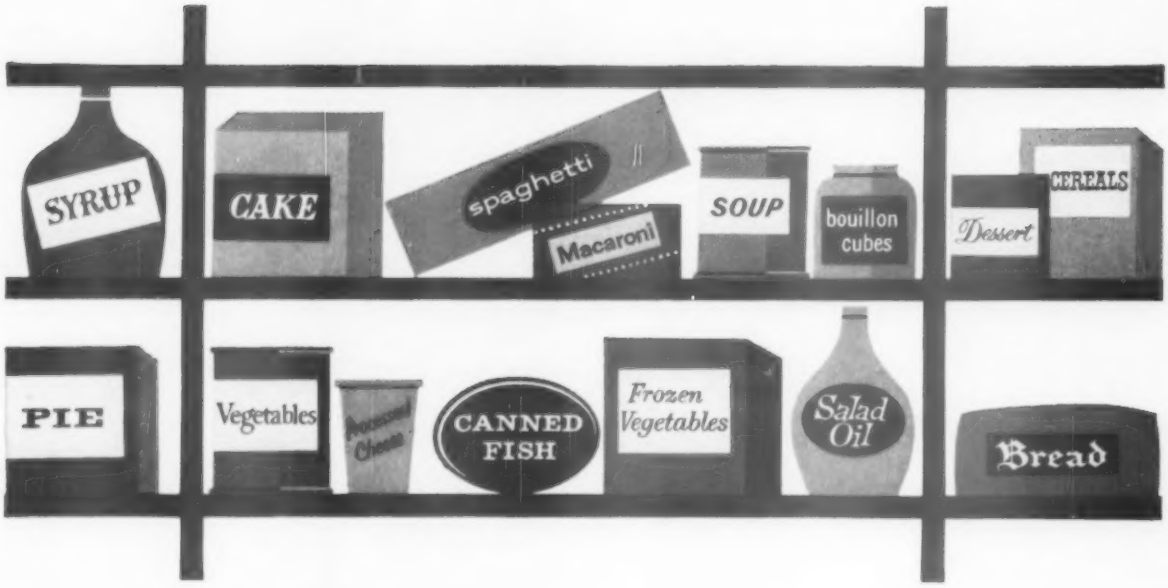

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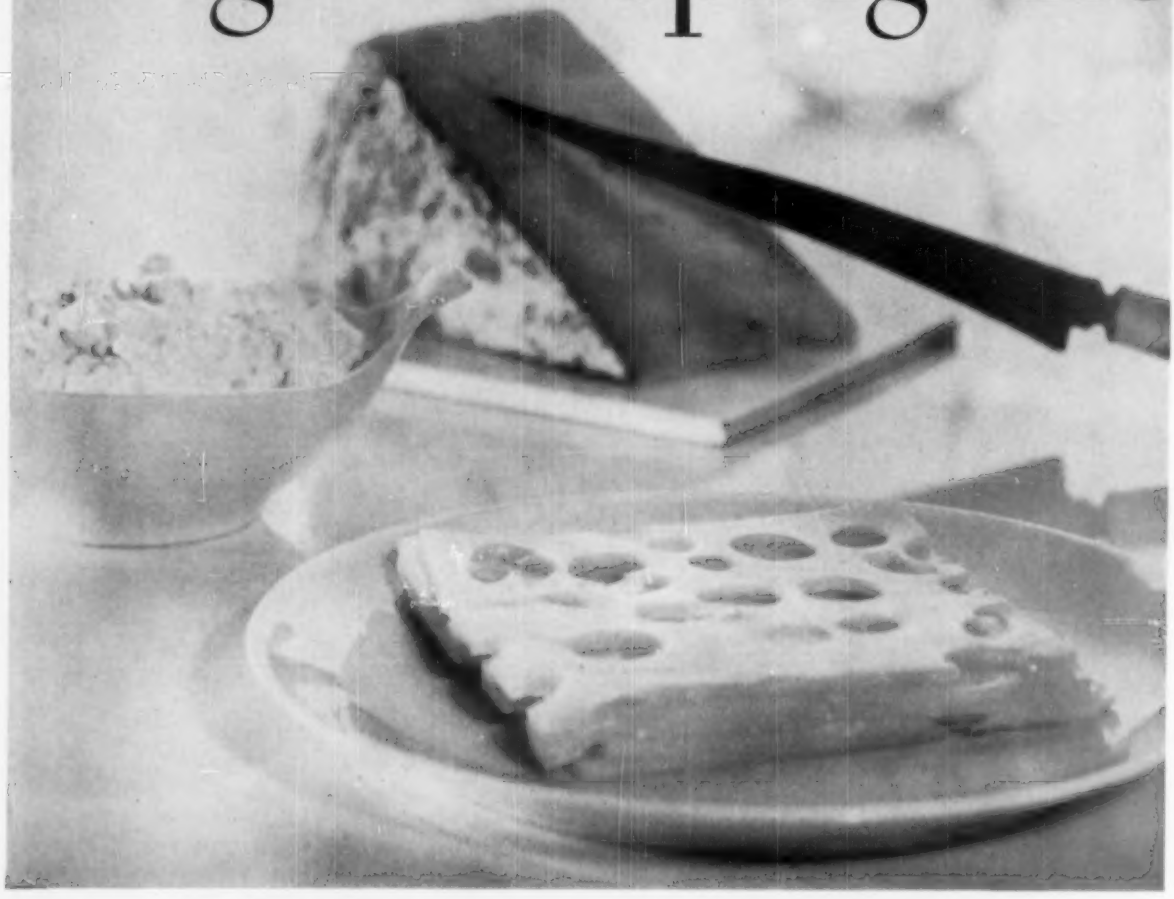

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The Food Industry in a Changing World*

Bernard L. Oser

Food and Drug Research Laboratories, Inc., Maspeth 78, New York City

(Manuscript received June 5, 1958)

IT IS A DISTINCT HONOR to have one's name associated, however remotely, with Babcock and Hart and the distinguished list of past recipients of the award bearing their names. I am truly appreciative of the honor which has been bestowed upon me.

The other day, when I was contemplating some of Babcock's accomplishments, I was impressed by the parallel which exists between what he did and the challenge which faces all of us as food scientists today. His development of a simplified scientific method to determine the fat content of milk was cited as "emancipating the dairy farmer from the rule of thumb." Today, food science may hold the key to another, and even more far-reaching emancipation: We have the opportunity to free mankind from the burden of two great fears—the fear of starvation and the fear of the scourge of war.

That's a bold statement. However, I am convinced of its fundamental truth. If we, as food scientists, appraise the situation which confronts mankind we will have to acknowledge that whether man's tenancy of the world continues depends upon how well our science progresses. If we are farsighted and diligent mankind's future is assured; if we are shortsighted or laggard the prospect of man's surviving for many centuries is dismal.

Consider where we stand today. This is the most crucial time in the history of the world. Within our own lifetimes man has propelled himself at speeds beyond that of sound; he has created new moons to explore the atmosphere above the earth; he has peered into the very depths of the atom; he has produced new forms of matter and is tapping new sources of energy; he has conquered the most devastating diseases; and he has discovered exquisite ways of destroying himself.

Our attention has been focused upon these remarkable achievements—and in terms of science they must be regarded as achievements. But we have paid but little heed to two matters which are vital to man's future existence. These are the explosive growth in the population of our planet and the clear inadequacy of present and immediately prospective resources to feed burgeoning mankind. I'm impelled to modify a Biblical reference somewhat and say, "What availeth a man to attain the moon and lose the world."

Let's consider for a few minutes the food problems which the world's fast growing population thrusts upon us. Then, a little later, we can appraise how this is related to the prospect of war or peace.

World population at about the time of Christ was somewhat under 300 million. By 1650 this had about doubled. This relatively modest increase was characterized by many ups and downs due to famine, war, and especially the ravages of disease. (For example, cholera killed a full quarter of the people in Europe in the 14th century.) During no half century before 1650 was the population gradient greater than 10%. But from an estimated 518 million people in 1650, humankind has now multiplied more than five-fold to 2.7 billion. What is more important, century by century the rate of rise has accelerated to 14 times the rate before 1650. If it continues we may anticipate a world population of between 7 and 9 billion a hundred years hence. One hundred years is a short time—from my birth to the time my grandchildren reach my present age.

We should be aware, of course, that the United States has played no minor role in the rate of population increase. In only the past quarter-century our population has grown from 125 million to over 170 million. This represents an increase of nearly 40% which is greater than India's, for instance, and even greater than that of the world as a whole. Estimates of what our population will be in 1975 range from 207 to 229 million—or 20% to 33% over the present level.

"WE ARE WALKING A NUTRITIONAL TIGHTROPE"

The food situation in this country is, of course, unique. And being so it tends to condition our perspective as far as the rest of the world is concerned. We are blessed in the United States with an overabundance of food and with excellent storage, transportation and processing facilities. In the past twenty years we have accomplished miracles in increasing production of grains, milk and eggs per acre or per unit weight of animal or feed. Our principal nutritional affliction is obesity. But that is far from being so in many other parts of the world. More than half of the world's population now struggles to receive fewer than 2200 calories per capita per day. Shortly before World War II there was sufficient food to provide a world average of 2300 calories per person. Now, despite 9% increase in fod output, the average available today is down to 2260 calories. We are indeed walking a nutritional tightrope.

Moreover, as I have intimated, whether we have war or peace may well depend on the adequacy of our food resources. It is not weapons that create wars. Rather it is disturbances—regional disturbances—of a social or economic nature which spawn wars. And they have at their roots the pressing needs for existence. The fight for freedom and independence may inflame nations to wage wars but smouldering beneath

* The Babcock-Hart Award Address, 1958. Presented at the 18th Annual Meeting of the Institute of Food Technologists, May 27, 1958, Chicago, Illinois, by Dr. Bernard L. Oser, recipient of this distinguished Award, which is sponsored annually by the Nutrition Foundation, Inc.

these aims is the struggle for a decent standard of living.

Look back over history and that truth becomes evident. We pride ourselves on being a peace-loving people. And we are. But we have had a rich continent to plunder. Suppose it had been otherwise; suppose our country had been barren and we had been hungry. Suppose we knew about—or saw—the fertile wheat fields of Canada to our north. Might not our necessity and our covetousness have overwhelmed us?

Greater world-wide production of foodstuffs is essential if we are to minimize the danger of war—a war of human extermination. As a corollary, I might suggest that any dictator or political leader finds it almost impossible to arouse warlike sentiments in the minds of comfortably fed people.

Let us take the optimistic view that neither nuclear warfare, famine, nor disease will seriously affect the predicted expansion in world population and then consider our available and potential food resources. We may assume that the physiological energy requirement of man may diminish somewhat with advances in mechanization, automation, and transportation. Nonetheless, it will probably never fall much below present levels of about 2800 calories per day. Where are the vast,—and they are vast,—quantities of food we will require for sustenance going to come from?

"WE SHALL HAVE TO FIND OR MAKE NEW FOODS"

Much of the earth's 36 billion land acres is not arable. In fact, less than one-tenth is under cultivation and, it has been estimated, present agricultural technology would permit at most a doubling of current world food production. Compare this with the anticipated trebling or quadrupling of population and it becomes obvious that some control of human multiplication must be exercised. This, however, is a subject fraught with emotional and sectarian implications and is outside the sphere of food scientists. Perhaps we may assume, however, that birth control measures will counterbalance population increases resulting from the conquest of disease. Some sort of population control, in any case, will be inevitable since as it has been so aptly put, "this battle between production and reproduction will never be won by production alone."

Nevertheless, every means will have to be taken to expand and conserve food supplies. Arable acreage must be wrested from the erosive forces of wind and water; hydroelectric, solar, and nuclear energy must be harnessed to irrigate desert areas; water must be drawn from subterranean sources or reclaimed from the sea at low cost. We may look hopefully toward control of rainfall, toward greater utilization of genetic selection of plant and animal varieties capable of resisting adverse climatic and soil conditions, and toward the extension and improvement of mechanization on the farm. It is advances such as these that have doubled production per farm worker in the United States in the past two decades.

We shall have to find or make new foods. These foods may little resemble the foods we now prefer or enjoy but they will furnish the energy, the amino acids, the vitamins, and the minerals for survival and reproduction. And, under the pressure of necessity, I warrant that man's palate will become adapted to accept them.

They may come from some of the thousands of known plant varieties never before consumed by humans, from artificially cultivated algae or yeasts, or from the sea. For instance, the krill or animal plankton which whales consume at a ton-a-day rate, abounds in the surface waters of the Antarctic. It is rich in protein but has not been exploited as food or feed for land animals. In passing, I might mention that Dr. Babcock once proposed that whales be domesticated, brought to ocean slips, and milked.

But in addition to tapping the natural sources and biological factories, future mankind will have to look to the chemical laboratory— or the chemical factory— for supplemental amino acids and calories as we do today for vitamins. Commercial synthesis of the essential amino acids, of which only a few grams per day would suffice to round out an otherwise protein-deficient human diet, is now forseeable. Synthetic fats and carbohydrates will also be made available by the time the demand becomes sufficiently great, thanks to the progress being made in organic chemistry, photosynthesis, and other types of enzymic synthesis.

OUR GREATEST POTENTIAL ALLY

The science of chemistry is our greatest potential ally. Through the study of soils, the fixation of atmospheric nitrogen, the development and improvement of fertilizers, the chemist has already rendered vital contributions to the agricultural revolution of our age. In recent years, too, significant strides have been taken in the effective use of chemicals to destroy plant and animal pests—including insects and rodents, pathogenic microorganisms and viruses and weeds. Chemicals have also been synthesized which prevent fruit from dropping to the ground prematurely and rotting, which prevent germination during storage (of potatoes, for instance) which induce defoliation, increase yields and produce seedless varieties of fruit.

It is impossible to calculate precisely the value of agricultural produce saved by pesticides alone. Some estimates, and they seem reasonable, place it at 20% of our entire United States production. It is ironical, however, that shortly after the introduction of DDT in Ceylon the death rate from malaria decreased while the birth rate and food production remained unchanged. This created an acute food shortage in that lush country. On the one hand science invents new compounds to fight off the Grim Reaper. On the other hand it creates the problem of feeding those whose lives have been saved.

I have mentioned various methods whereby world food production can and must be expanded and the increasingly important role that chemical science must play. Passing mention must also be made of the

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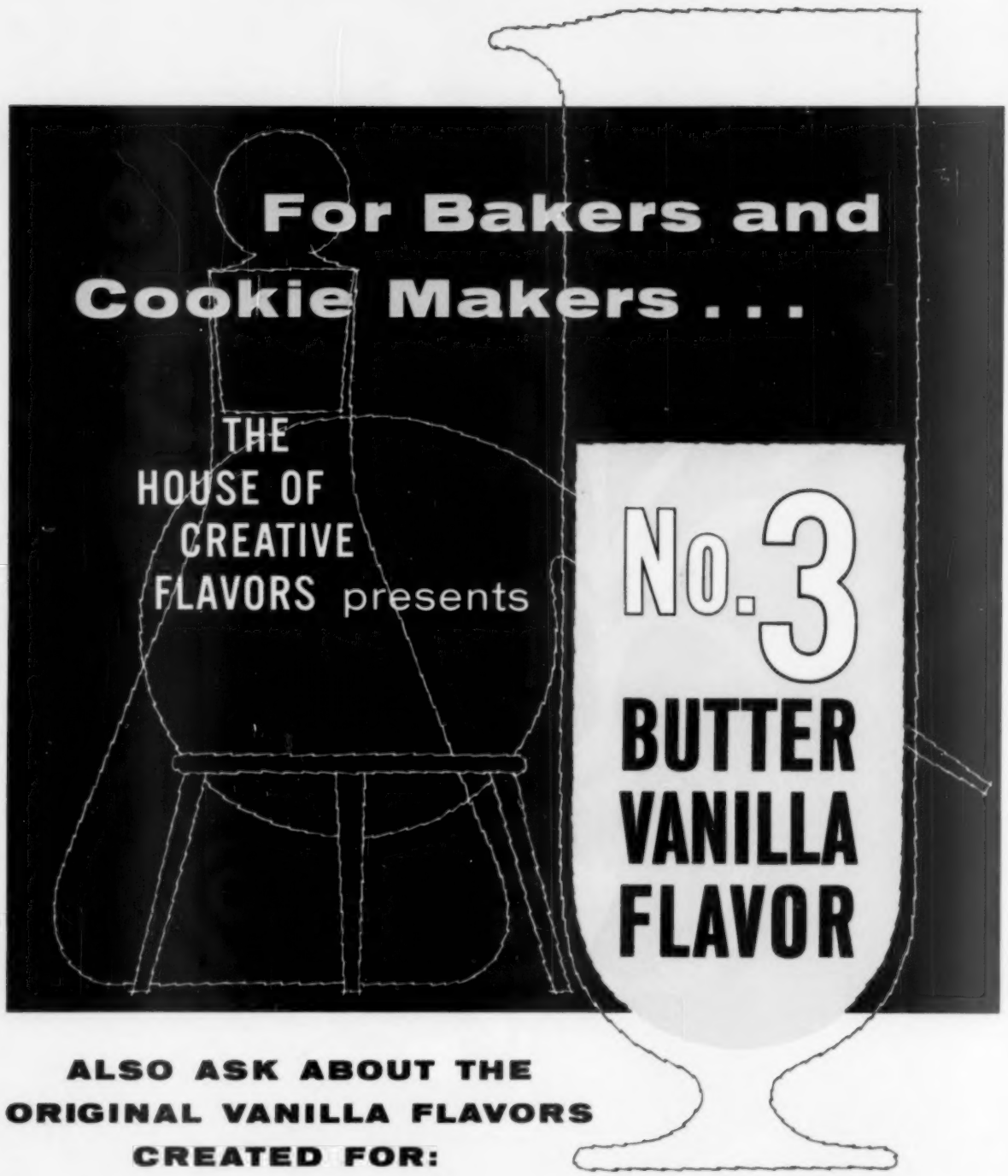

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use of chemicals to protect foods from contamination, dehydration, and spoilage after leaving the farm or factory; to retain or impart nutritive value; to maintain color or clarity; to improve flavor, texture or attractiveness; to facilitate preparation in the kitchen; and to effect economies in production and distribution to consumers.

These functional uses of chemicals have contributed greatly to expanding the variety and wholesomeness of our foods. Parenthetically, this has also been important in coping with the problem of the shortage of domestic household help. Today there are more than 20 million working women in the United States, so the advantages of foods that keep well, and hence require less frequent shopping, and which contain built-in convenience and speed of preparation are obvious. The food additive which all housewives and many husbands appreciate most is, in fact, antidrudgerine.

In spite of the established virtues of food additives there is a growing tendency to look at them askance as though they debase foods. The rigid structure of our laws has cast most of these substances as poisons. True they cannot themselves be eaten as ordinary foods. Even when the amounts contained in foods are so trivial as to present no hazard to human health, the law forbids the presence of additives, regardless of how useful they may be, unless they are actually essention to production. The fact that an exception is made in the case of certain pesticides, which are unquestionably poisonous, seems paradoxical.

It can hardly be denied that caution must be exercised in effecting basic changes in the principles governing our food supply. However—out of sheer necessity—people generally and health officials particularly will have to abandon the attitude of suspicion toward *all* change. We will have to gear our thinking, legislative and otherwise, to technological and agricultural progress if we are to satisfy human needs in the days to come. The scientist must be encouraged to pursue his research with the realization that he will not have his progress thwarted by overzealous enforcement agencies which feel themselves bound by stagnant or archaic laws.

Consider for a moment what science, and particularly chemistry, has accomplished for mankind in other areas. A few decades ago we were following the same practices in clothing ourselves as did primitive man. We sheared sheep, tediously unravelled the cocoon of the silk worm, or waited a full season for a bit of fluff to ripen on a cotton plant. Now we can make textile fibers by the ton from plentiful chemical raw materials. To produce rubber we had to tramp through steaming jungles, draw the sap from trees, coagulate it over a smoky fire and ship the gum half way round the world.

To provide medicinals we had to seek out exotic botanicals, harvest, ship and laboriously extract some of their ingredients. Chemical progress has changed all that—and for the better. Yet I venture that little of that progress, and those benefits, would have come to be ours if scientists in those fields had been as restricted by status quo regulations as we food scientists. Such regulations do not, of course, develop of themselves.

"BLOOD-THIRSTY JOURNALISTS," CRACKPOTS, AND CRUSADERS

Much of the popular writing on the subject of chemicals in foods is buncombe. It is fabricated from speculations, half-truths, and obsolete information. Nevertheless the doubts, the fears, and the confusion engendered by these sensational outpourings are not offset by the more sober but less exciting facts which seldom reach the public. Consequently emotional pressure is brought to bear on legislative representatives and administrative agencies who are forced to hearken to the "will of the people," however ill-informed they may be.

The responsibility for this situation must be placed not only on "blood-thirsty journalists" or crackpots but also on some quite competent scientists with a "strong sense of personal greatness." They fancy themselves as being persecuted when colleagues reject their unproved postulations and prejudices. With all the sincerity, and all the zeal of crusaders, they vent their spleens in the form of ill-considered, ill-tempered, or peevish statements to feature writers.

It would be in the common interest if views on controversial scientific questions were either resolved or explained by groups of competent scientists in responsible agencies such as the National Academy of Sciences-rather than leaving complex scientific questions to the judgment of the general public which, for lack of specialized training, is incapable of separating the wheat from the chaff.

THE FUTURE BELONGS TO CREATIVE CHEMISTRY

Let it be remembered that science is but one constituent of progress. To reap its fruits we must have boldness and courage, as well. Primitive man had to use the process of trial and error to select and prepare foods. He was his own guinea pig and often to his great distress. We owe to him our knowledge of poisonous berries, mushrooms, roots, nuts, legumes, and so on ad infinitum. Today, however, we have remarkable research tools and refined biological methods to insure the safety and wholesomeness of new foods and food ingredients. We do not have to tarry for years or generations for acute or subtle dangers to manifest themselves. Present day risks are minor risks and we can afford to take them to win the greater benefits that await us and our descendants.

In our concern lest a few parts per million of a useful food additive violate the letter of the law, let us bear in mind that if we are to produce and protect food for future billions, the advances of chemistry must be capitalized upon. Additives are important today and always will be. But the "food chemicals" of tomorrow will be eaten by the pound and by the ton. They will be the synthetic proteins, fats, and carbohydrates that will augment the cruder products of nature.

A negative or shortsighted attitude toward chemicals will only delay—but not prevent—the day when creative chemistry will come to the rescue of a world population threatened by mass starvation or the strife of mass extermination. We, as food scientists, and our colleagues in the days ahead, have a responsibility to all mankind—to the future of the world.

The Role of Lysine in Cereal Food Products

Charles Feldberg and Carl P. Hetzel

Chas. Pfizer & Co., Inc., Brooklyn, New York

(Manuscript received May 12, 1958)

SINCE OSBORNE AND MENDEL *(33, 34)* showed that cereal proteins are deficient in lysine, the improvement of cereal products by addition of amino acids has been studied intensively. Until recently these studies were mainly of academic interest, since their practical application had been curtailed by the lack of many of the amino acids, especially lysine, in commercial quantities. Within the past year, a number of firms have announced the availability of lysine in commercial quantities. This fact has served to intensify the study of L-lysine in human feeding problems and nutrition. Concurrent with this development a number of large food firms have entered the market with lysine-fortified food products *(17)*. It now appears that lysine may have an impact on American nutrition similar to that of the B vitamins.

PRODUCTION METHODS

A number of methods are now used to synthesize L-lysine. One of these utilizes a chemical synthesis wherein the basic raw material is dihydropyran *(44)*. Through the intermediate polytetramethylenehydantoin, a DL-lysine mixture is obtained which is resolved by L-glutamic acid *(15, 16, 39)* to yield L-lysine with residual amounts of the D-isomer.

In October, 1956, the first commercial production of lysine by controlled fermentation was announced. The process *(10, 11, 12)* is a unique two-step technique, utilizing two different microorganisms. In the first step a mutant of *E. coli* acts on a substrate of glycerol, corn steep liquor salts and water to yield diaminopimelic acid. In the second step, a special strain of *A. aerogenes* is added, together with toluene, which breaks open the cells of the bacteria, releasing the enzyme diaminopimelic acid decarboxylase. This enzyme converts the acid to lysine. With this process, the yield is stereochemically homogeneous; the L-lysine is formed completely free of the D-form. After recovery and purification, the product yield is of exceptionally high purity, comprising at least 98% L-lysine.

There are other methods of producing lysine, such as the acid hydrolysis of dried blood and the subsequent extraction of the natural lysine *(22)*, but it is believed that these procedures will be of only minor commercial importance in the future.

THE ESSENTIAL AMINO ACIDS

Some types of bacteria, given a good supply of a single amino acid, can synthesize all the others *(30)*. Plants need no amino acids at all in their "diet," since they can synthesize them from basic sources of nitrogen and carbon. Most animals, on the other hand, are not nearly so gifted; chickens, for instance, cannot synthesize 11 of the amino acids they must have to stay alive *(37)*.

This is true of man as well. A human adult must obtain 8 preformed amino acids from his diet (threonine, valine, leucine, isoleucine, lysine, methionine, phenylalanine and tryptophan). Some of these, such as lysine, must be obtained entirely from outside sources; others, such as methionine, can be replaced in part by the nonessential amino acid cystine. However, this substitution is not sufficient to replace completely that which is lost in the normal dynamic processes that maintain life.

Because these 8 nutrients cannot be synthesized by the body in required amounts, they are called the *essential amino acids*. All of the essential amino acids must be supplied in correct proportions simultaneously, since lack or deficiency of any one effectively stops complete utilization of all the others *(9, 12, 19, 43)*.

This simultaneous supply of amino acids is not only important for growth but for adult maintenance as well. Protein molecules which are used up during breakdown due to natural life processes must be replaced by a synthesis which, like growth, requires the simultaneous presence of all requisite amino acids.

Deficiency of a single amino acid, as manifested by negative nitrogen balance, can develop in humans and laboratory animals in as little as one day after intake of the amino acid is cut off. This is the most rapid development of deficiency symptoms so far reported for any known nutrient, and reemphasizes the need for ensuring the proper intake of essential amino acids as well as of vitamins and minerals *(8)*.

NATURAL SOURCES OF LYSINE

High- vs. low-quality protein. In most animal proteins, the essential amino acids are present in proportions which can be efficiently utilized by the body's anabolic centers for tissue synthesis. These well-balanced proteins have been called "high-quality proteins." In most cereal vegetable proteins, however, one or more of the essential amino acids is usually deficient and these proteins are called "low-quality proteins."

It is now an accepted fact that in cereal proteins, especially wheat, the inadequate supply of lysine is the factor most limiting to their full nutritive value. In addition to the fact that cereal proteins are naturally deficient in lysine, their sensitivity to heat has also been demonstrated *(14, 31, 32)*.

The lysine values for ready-to-eat whole wheat, corn, oat and rice breakfast foods, ranged from 30 to 58% less than the values reported for the whole grains *(6)*. This decrease in lysine may be caused partially by heat treatment in processing *(55)*.

Although cereals and grains are important foods which contribute significantly to modern nutrition, they are recognized to be inferior to animal foods such as milk, fish, and eggs. Not only do cereal foods contain less total protein than animal foods, but also cereal protein, either naturally occurring or processed, is incomplete in amino acid composition as compared with animal protein.

IMPROVEMENT OF CEREAL PROTEIN

Wheat. Through judicious supplementation of wheat protein with lysine, it has been demonstrated that its quality and efficiency can be markedly improved. Weanling rats fed a diet of wholemeal adequately supplemented with vitamins and minerals had a faster growth rate than those fed white flour crumbs also enriched. This growth difference was attributed to the slightly higher lysine content of wholemeal as compared with white flour. If this deficiency is corrected by supplementation with lysine, weanling rats grow as rapidly on white crumbs as on wholemeal when these are the main or exclusive sources of protein in the diet *(25)*.

In comparing the protein quality and quantity of white bread and protein bread with that of egg, Stare *(45)* stated that 3 slices of ordinary white bread equal the protein of one egg in terms of total quantity of

protein. However, the quality of the bread protein is only about a third that of egg. Therefore, 9 slices of ordinary white bread are required to equal one egg in terms of quality and quantity of protein. If white bread is supplemented with lysine, only 5 slices will equal one egg.

In a similar manner protein breads can be improved by lysine supplementation. A quantity of protein equivalent to one egg is supplied by 2 slices of typical protein bread, but a correction for quality indicates that about 5 slices are required. If the protein bread is supplemented with lysine, only 3½ slices would provide the same protein quantity and quality as one egg. On this basis, lysine-supplemented protein bread has a protein efficiency 2½ times that of nonsupplemented white bread.

Rosenberg and Rhodenburg *(41)* investigated the effect of increasing amounts of lysine on the nutritional value of bread protein. They found that adding 0.2% L-lysine to a dried bread diet, containing 3 parts nonfat milk solids per 100 parts of flour supplemented with fat, salts and vitamins, improved the average gain in weight of weanling rats after 5 weeks from 32% to about 75% of the average gain on the stock diet. In another study these workers showed that in weanling rats, as far as growth is concerned, the only amino acid deficiency in commercial white bread is lysine *(42)*. Further supplementation with valine, threonine, and methionine was without additional growth effect.

Hutchinson and associates *(24)* conducted a similar experiment, except that the bread ration used did not include the 3 parts of nonfat milk solids. In these studies the optimum growth response was found with an L-lysine supplement of 0.25%. Three parts of nonfat milk solids will provide approximately 0.082% L-lysine; therefore, these results can be closely correlated with those of Rosenberg.

Sure, studying rat growth with whole wheat cereal breakfast food *(48)* and with whole wheat *(47)* fed at an 8% protein level, obtained a substantial increase in protein efficiency when lysine alone was added. Further increases were noted when valine and threonine were added to the lysine-supplemented cereal. However, Rosenberg *et al. (42)* found no further improvement in growth when valine and threonine were added to a lysine-supplemented white bread diet fed at a 12.5% protein level. These workers concluded that the difference in protein levels may account for the variations between their study and those of Sure; they believe that as far as rat growth is concerned, lysine is the only amino acid deficiency in commercial white bread.

Sure *(51)* also noted that the increased protein efficiency of white bread supplemented with dried food yeast is attributable only to the lysine supplied by the yeast.

Howard *et al. (21)* studied the relative supplementary value of various food proteins and lysine for wheat flour. The authors concluded that lysine is the most limiting amino acid in diets in which wheat flour supplies the major source of protein, and that the rate of growth of rats on these diets is not affected by the inclusion of other amino acids furnished by the supplementary protein. The supplementary proteins tested were lactalbumin, nonfat dry milk solids, soybean proteins and wheat gluten. On a weight basis L-lysine monohydrochloride is the supplement of choice.

Jahnke and Schuck *(26)* studied growth response and liver fat deposition in rats fed diets consisting of bread mixtures containing three levels of nonfat milk solids, with and without 0.25% L-lysine based on the weight of the flour. With 3 parts of nonfat milk solids per 100 parts of flour plus 0.25 parts of lysine, they obtained an improvement in growth comparable to that observed with 12 parts of nonfat milk solids in bread diets.

Sure *(53)* found that the addition of 0.4% L-lysine to milled hard wheat flour improved the protein efficiency ratio by 147% and growth by 198% over that of unsupplemented wheat flour. Further substantial increases in growth were noted with threonine, valine and vitamin B_{12}. This same investigator found similar results with enriched milled wheat flour supplemented with 0.4% L-lysine *(52)*.

Hutchinson *et al. (19)* found that in weanling rats the difference between the nutritive value of the protein of wholemeal bread and that of white bread was due mainly to the higher lysine content of wholemeal bread. When the lysine content of the white bread was raised to the level of wholemeal bread by additions of L-lysine, both diets resulted in equally improved rat growth. Once this lysine requirement was satisfied, there was no evidence of any other limiting amino acid.

Rice. Rice, which provides a major portion of the nutrients ingested by a wide segment of the world's population, contains a protein which is incomplete in the levels of essential amino acids present. This fact has motivated many researchers to investigate the possibility of improving the protein of this food by supplementation with one or more amino acids.

Pecora and Hundley *(36)* improved the natural rice protein in polished rice by supplementing with 0.2% L-lysine and 0.12% L-threonine. These levels of amino acids produced a growth response in rats three times that produced by an unsupplemented rice diet.

Kik *(27)* supplemented rice bran and rice polish, important by-products of the rice milling industry extensively used in the feeding of livestock, with 0.2% L-lysine, 0.2% DL-threonine and 0.1 mcg. vitamin B_{12}, and found that these grains were improved by this supplementation.

Hundley *et al. (23)* studied nitrogen balance in 5 normal adults to evaluate certain amino acids as supplements in rice diets. This study showed a mixture of effects which, according to Hundley, indicated that a primary deficiency in these diets was a need for more nitrogen, from essential or nonessential amino acid sources. Lysine alone, however, seemed to exert a specific effect in some subjects over and above that which could be explained by contribution of nitrogen only. Threonine did not show a specific effect of this type, and the authors pointed out that, with respect to improvement of rice protein utilization, the human

adult is clearly unlike the growing rat which needs both lysine and threonine for this purpose.

Rosenberg and Culik *(40)* more recently found that the nutritive value of the protein in white polished rice could be significantly improved by additions of small amounts of lysine alone. The addition of 0.05 to 0.10% of L-lysine monohydrochloride to a 90% precooked white polished rice diet significantly improved the growth rate and efficiency of food utilization of weanling rats.

Rye. Sure *(51)* found that the addition of lysine alone and threonine alone to a rye flour containing 8% protein produced little growth response in rats. However, the addition of a combination of 0.25% L-lysine and 0.2% threonine to this diet yielded a significant increase in growth and protein efficiency.

However, in a more recent study, Stromnaes and Kennedy *(46)* showed that lysine alone significantly increased the protein efficiency of rye bread. In rat growth studies, they determined the protein quality of rye bread and of the unbaked ingredients, using supplements of 0 and 5% nonfat milk solids and 0.166% L-lysine. Supplements of milk solids increased the protein efficiency ratio 9% for the bread and 11% for the unbaked ingredients. Lysine increased the protein efficiency 21% both for the bread and the unbaked ingredients.

Breakfast cereals. Cereal breakfast foods, due to their ease of preparation and content of many essential nutrients, have gained wide acceptance in our modern American diet. The fact that the grains from which these cereals are produced contain proteins which are deficient in one or more of the essential amino acids, chiefly lysine, have led many authorities to believe that they can be greatly improved by amino acid supplements. The formation of nonutilizable configurations of essential amino acids during processing lends weight to these views.

Sure *(50)* studied the nutritional value of the protein in various commercial cereal breakfast foods using the rat growth method to determine the protein efficiency ratios of the various products. It is interesting to note that, of 15 cereals tested, only 4 were considered adequate in regard to protein efficiency. In 6 of these cereals not only was the protein efficiency poor, but also a great proportion of the animals in the test groups subsisting on them died. It is evident from this study that many of these cereals alone were of extremely poor protein quality, even though when fed with enough milk the resulting mixture may have supported growth.

Sure *(49)*, in noting that commercial cereals are poor in protein quality, also stated that although cereal usually is fed with milk, infants allergic to milk must use it as a gruel without milk. Also, Albanese *et al. (2, 3)* observed that certain infants manifest symptoms of malnutrition because they do not utilize the lysine of milk efficiently. Milk protein is well balanced in essential amino acids and when it is used to improve the lysine content of cereals, the resulting protein mixture is inferior to milk protein in lysine content, and the amino acids, other than lysine, are present in excess. These excess amino acids will not be used in tissue synthesis. It is not possible to raise the amino acid content of cereal proteins to animal protein levels by mixing cereal proteins in the diet *(59)*.

In studies with various Pablum cereals, Sure *(49)* found that 0.2% L-lysine improved the protein efficiency ratio as measured by rat growth in the mixed cereal of oatmeal and barley. Additional improvement was noted with supplements of vitamin B_{12}.

A contributing cause of poor protein quality in commercial cereals due to processing was noted by Patton *(35)* who found that the processing of proteins produces a new lysine linkage which is either not digestible by enzymes or it is so slowly digested that part of the lysine enters the blood stream too late to participate with the rest of the assimilated amino acids in tissue formation.

A study by Westerman *et al. (56)* showed that diets containing milk, eggs and cereal could be improved by addition of lysine.

APPLICATION OF LYSINE-FORTIFIED CEREALS

A condition of malnutrition in children called Kwashiorkor has been associated exclusively with Africa but is also found under other names in South America, India, Indonesia, Italy, Spain, France and Central Europe *(1)*. A considerable amount of evidence is at hand showing that this condition is due mainly, if not entirely, to deficiency of high-quality protein in the diet *(13)*. Unfortunately, high-quality protein is generally not available in areas where this condition is prevalent. Furthermore, dietary habits in these areas are rigid and regimentation of diets to conform to high nutritional standards is difficult. Efforts by various health agencies to include high-quality animal proteins in these diets have met with resistance. Provision in the diet of lysine-enriched cereal proteins is a means of improving dietary amino acids balance and over-all protein efficiency *(58)*. This view seems practical since the addition of a few grams of amino acids to diets would involve less change in food habits than large additions of other proteins.

In a recent study of malnutrition in the tropics, Loughlin and Wetzel *(28)* observed the effect of a one-gram lysine supplement daily in Haitian children who were in growth failure. These children showed significantly greater gains in height and weight when the diets were supplemented with lysine as compared with children in the control group.

In discussing their results, Loughlin pointed out that the adults in the tropics generally consume starchy diets grossly inadequate in protein. Diets of native children in the tropics are likely to be markedly deficient in both calories and protein.

The substitution of dried skim milk has been attempted by certain agencies in various tropical countries. It is seldom realized that deficiencies can result, however, when such milk is the principal or sole food of the infant. When planning to improve the nutrition of tropical children it should be noted that dried milk, even when stored in cans at ambient tempera-

tures, may lose three-quarters of its biological value within a year. This loss is chiefly in amino acids (some are destroyed while others become biologically unavailable) and in certain vitamins, particularly pyridoxine. In view of these obstacles, Loughlin believes that supplementing the diets of tropical children with growth-promoting substances may provide a new pathway toward solving some of the problems brought on by lack of nutritious food.

There is considerable evidence on hand to indicate that animal protein deficiencies, even in some areas of the United States, constitute a major nutritional problem *(29)*. This dietary defect is not limited to overt situations of our lower economic groups, but is also widespread in the children and women of families of relatively high incomes. It is conservatively estimated that 20% or more of our population suffers from varying degrees of protein deficiency, which may occur during any stage of life especially when anabolic processes are going on at accelerated rates, as in the growth and development of infants and children, in pregnancy and in convalescence *(1)*. Diets rich in protein seemingly provide an obvious solution to the problem but, unfortunately, too often those who need high protein diets most resist eating high-quality protein in sufficient quantities to meet their dietary needs because of food habits or other reasons.

Cereals fortified with lysine could be of value in geriatric nutrition for people who are allergic to milk or whose defective dentition requires a soft nutritious source of protein *(19)*. Albanese *et al. (4)* in studies with humans found that supplementing the diet of elderly people, who were under nutritional stress, with 600 to 900 mg. of L-lysine per day, divided between meals, greatly enhanced the biologic value of diets, especially those low in meat proteins. Amino acid fortification of cereal foods may also be of significant benefit in diets during pregnancy when a protein intake of 85 g. a day of high-quality protein is desirable for the good health of both mother and child *(18)*. Some recent dietary surveys indicate that many pregnant women in this country do not receive adequate supplies of protein for optimum well-being *(5, 7, 57)*.

In surgical patients a 30 to 60% increase in protein intake has been recommended by Rhoads *(38)* in conjunction with a 25 to 30% increase in calories. After extensive surgery these needs are doubled. In these instances cereal proteins, supplemented with essential amino acids such as lysine to improve their balance, together with high-quality animal proteins could satisfy these greatly increased requirements.

Recently, Albanese *(1, 2)* reported that a high percentage of infants who failed to respond to conventional formulas grew normally after the addition of lysine to their diets. Holt and Snyderman *(20)*, however, reported that the lysine requirement of the normal infant is 90 mg. per kg. of body weight, much less than that supplied by the average diet. Howe *(22)* points out that these findings are not necessarily contradictory since it is possible that partial failure in digestion or absorption has limited the actual intake of lysine by retarded infants and that additional free lysine corrects this deficiency.

SUMMARY

It is evident that supplementation of wheat-based foods with lysine will improve their protein quality and will result in improved growth and tissue synthesis. These results are to be expected since the protein of wheat is naturally deficient in lysine. In addition, the commercial processing of these foods further lowers their lysine content.

Lysine supplementation also has improved the protein of rice, rye, and breakfast cereals. It may be possible in the future to improve diets in underprivileged areas of the world by feeding lysine-supplemented cereals.

Lysine-supplemented cereals may be recommended during periods of growth, pregnancy, lactation and stress, such as recuperation from surgery and illness, and for geriatric feeding.

Any supplementation of cereal foods with the most limiting amino acid and addition of which will improve the natural amino acid pattern should be considered to be sound nutritional practice and one which should be encouraged. Thus, the protein of these foods will be fully utilized by the body for the function which they should fulfill and which they can only partially do at present.

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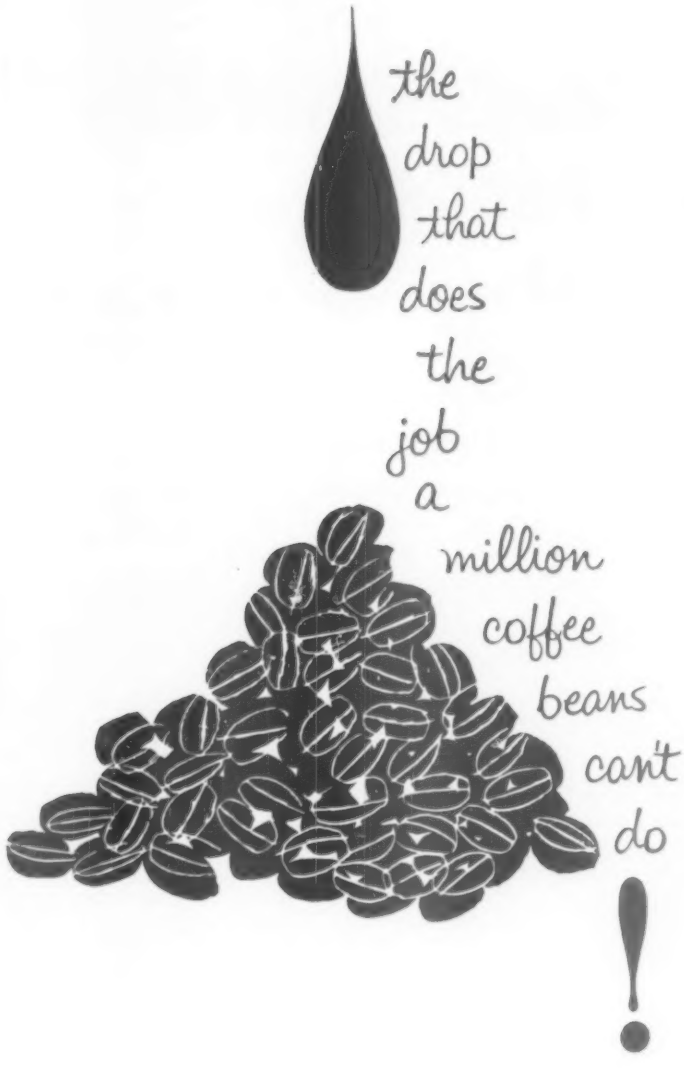

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Vitamin K_5 As a Food Preservative*

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MANY CHEMICAL food preservatives suffer from the fact that they may be harmful to the consumer when used in effective amounts or detrimental to the quality of the food product. Some are objectionable for both reasons. This problem has stimulated efforts to find preservatives low in toxicity, high in antimicrobial activity, and comparatively easy to bring into compliance with federal and state food laws. Lately, interest has developed in the use of natural food constituents, such as vitamins, for food preservation since they are compounds that occur in normal human metabolism. Some are necessary to health. Consequently, they should be expected to be non-toxic to the consumer when used in moderate amounts.

Vitamin K_5 (2-methyl-4-amino-1-naphthol hydrochloride), an analog of vitamin K, is one of these compounds. Pratt *et al. (4)* found that vitamin K_5 had a marked inhibitory activity toward a number of microorganisms. The bactericidal action of K_5 toward Gram-positive and Gram-negative organisms has been reported by Shartzman *(5)*. The activity of vitamin K_5 appears to depend on an intermediate product of oxidation by air which is formed immediately upon dissolving the compound *(5)*.

The term vitamin K, derived from the German and Scandinavian expression "Koagulations-Vitamin," has been applied to the compound recognized by Dam *(3)* in 1929 as one which would decrease blood clotting time. The K vitamins are found in the green leaves, as of alfalfa, spinach, kale, and others, as well as in cheese, egg yolk, liver, and tomatoes.

Athanassiadis, Caspar, and Yang *(1)* showed that 8 p.p.m. of vitamin K_5 completely inhibited secondary fermentation in light sweet wine for a period of 30 days. Casper and Yang *(2)* found that 30 p.p.m. of vitamin K_5 were more effective than 100 p.p.m. sulfur dioxide in preventing volatile acids production in light sweet wine.

The effectiveness of low concentrations of vitamin K_5 in preserving wine indicates that it should be an effective preservative for other foods. Therefore, work was started to evaluate the effectiveness of vitamin K_5 on cheddar cheese spoilage organisms, cottage cheese, strawberry jam, mushroom sauce, table syrup, frankfurters, and crab meat. In another series of tests the heat stability of vitamin K_5 was established both in model systems and in a food product. Comparison of the effectiveness of vitamin K_5 with vitamin K_3, sorbic acid and a commercial anti-mold, anti-bacterial, and anti-ferment preparation was also demonstrated.

* Approved for publication by the Director of the Oregon Agricultural Experiment Station as Technical Paper No. 1131. Contribution of the Department of Food and Dairy Technology.

EXPERIMENTAL

Effectiveness of vitamin K_5. The effectiveness of vitamin K_5 in preventing mold growth was compared with that of sorbic acid, vitamin K_3, and a commercial anti-mold compound. A heavy spore suspension of molds was obtained from cheddar cheese and mixed thoroughly in sterile water to give a uniform inoculum. One loopful of this suspension was used to streak Petri dish cultures of agar media containing various concentrations of the different preservatives. Duplicate samples and controls were prepared. The plates were incubated at 27° C. (80.5° F.) and observed for the amount and type of mold growth.

Effect of heating. The effect of heating vitamin K_5 and sorbic acid to 200° F. for 2 minutes was studied. Stock solutions of vitamin K_5 and sorbic acid were heated in a water bath and then allowed to cool to room temperature. Measured amounts of the stock solutions were then used as described above to prepare plates containing different concentrations of vitamin K_5 and sorbic acid. Duplicates and controls were prepared. These plates were incubated at 27° C. and observed for amount and type of growth after inoculation with a suspension of cheddar cheese organisms by the method used above.

Mushroom sauce. Mushroom sauce was prepared according to a commercial method by blending fresh mushrooms in a Waring blender. One teaspoon of salt and one tablespoon of tapioca flour were added per pound. This was heated in a double jacketed kettle until the sauce thickened and then placed in 6 oz. glass jars. Vitamin K_5 was added in concentrations of 0, 10, 30, 40, 50 and 100 p.p.m. and mixed into the sauce. The jars were sealed and processed for one hour at 250° F. and allowed to cool. Samples were opened after cooling and observed for spoilage.

Strawberry jam. Strawberry jams of 45, 55, and 65% soluble solids were prepared. Vitamin K_5 was mixed into these samples while they were still warm and thin. Concentrations of 0, 10, 20, 30, 40, and 50 p.p.m. were used. Samples were stored in one-half pint wide-mouth jars exposed to the atmosphere at room temperature. They were observed periodically for mold growth and other spoilage.

Cottage cheese. Cottage cheese consisting of 5 lbs. of dry curd, 3 lbs. of cream, and 1% by weight of salt was treated by the addition of 0, 10, 20, and 30 p.p.m. of vitamin K_5. K_5 was mixed with the cream prior to the addition of the curd. Samples were packed in the standard pint paper cartons. One set of samples was placed in the refrigerator at 38° F.; another set was stored at room temperature (about 72° F.). Observations of mold growth were made regularly.

Crab meat. Frozen and thawed crabmeat was treated with a 5% brine containing vitamin K_5 in the concentrations ranging from 0 to 100 p.p.m. The samples were packed in glass jars and stored in the refrigerator at 38° F. Observations were made daily.

Frankfurters. Vitamin K_5 was tested on frankfurters to study the effectiveness of the vitamin in controlling mold growth on this product. Frankfurters were treated with K_5 in two different ways. One set of samples was prepared by mixing the vitamin with the meat emulsion at the concentrations of 50 and 100 p.p.m. prior to making into frankfurters. Another set of samples of untreated frankfurters was soaked in vitamin K_5 solutions of 50 and 100 p.p.m. for 10 minutes and air dried. Samples were stored in paper cartons at room temperature.

It was found that neither of these methods was effective in preventing mold growth on frankfurters. Treated samples were observed to become moldy as rapidly as the control samples.

It was then decided to isolate the molds from the spoiled frankfurters under study to determine whether they are resistant to vitamin K_5, or the methods of K_5 application were faulty. Concentrations of vitamin K_5 of 0, 30, 40, 50, 60, 70, 100 p.p.m. were prepared using nutrient agar cultures in Petri dishes. Plates were streaked with the mold suspension obtained from the spoiled frankfurters, incubated at 27° C., and observed for growth.

Table syrup. Samples of a 70% soluble solids commercial table syrup were treated with 10, 20, and 30 p.p.m. of vitamin K_5. A control was also included. These samples were inoculated with one loopful of a heavy mold spore suspension obtained from spoiled cheddar cheese, and then incubated at room temperature and observed.

RESULTS AND DISCUSSION

Effectiveness of vitamin K_5. The effectiveness of vitamin K_5 in preventing growth of molds obtained from the surface of cheddar cheese was compared with that of sorbic acid, vitamin K_3, and a commercial anti-mold agent. Results are shown in Table 1.

It is seen that vitamin K_5 and sorbic acid completely provented mold growth at higher concentrations with vitamin K_5 10 times as effective as sorbic acid. The commercial anti-mold compound had a slight inhibitory effect at 1000 p.p.m. (The manufacturers' recommended effective concentration is 5000 p.p.m.). Based on these data, vitamin K_5 is 100 times and sorbic acid 10 times more effective than the commercial preparation.

Vitamin K_3, though a member of the K vitamin group, was not effective in controlling mold growth.

Effect of heating. The effect of heating vitamin K_5 and sorbic acid to 200° F. for two minutes was studied. It was found that heated samples of K_5 were as effective for the control of cheese molds as unheated samples. Sorbic acid was ineffective in controlling mold growth after heating at the concentrations used as shown in Table 2.

It is seen that vitamin K_5 is effective against cheese molds at the concentration of 40 p.p.m., heated or unheated. Sorbic acid is effective at 400 p.p.m. unheated only. These tests were made at the incubator temperature of 80° F. It is believed that when a regular cheese storage temperature (45° F.) is used, the effective concentrations shown can be reduced substantially.

TABLE 1

The amount of mold growth observed on nutrient agar cultures containing the indicated amount of preservative at various dates after incubation at 27°C.[1]

Treatment	Concentration p.p.m.	Days of incubation at 27° C.				
		2	3	5	7	10
Vitamin K_5	100	—	—	—	—	—
	50	—	—	—	—	—
	10	++	++	+++	++++	
Sorbic Acid	1000	—	—	—	—	—
	500	—	—	—	—	—
	100	++	+++	++++		
Commercial Anti-mold Agent[2]	1000	—	+	++	+++	++++
	500	+++	++++			
	100	++++	++++			
Vitamin K_3	100	++++				
	50	++++				
	10	++++				
Control		++++				

Legend: — No growth, + Slight growth, ++ Moderate growth, +++ Heavy growth, ++++ Very heavy growth.

[1] Observations of duplicate samples.

[2] The commercial anti-mold, anti-bacterial, and anti-ferment compound contains tri propionin, sodium benzoate, methyl and propyl para-hydroxy benzoates, dipropylene dipropionate, and propylene glycol. Effective dosage recommended by the manufacturers: 5000 p.p.m.

Mushroom sauce. Due to its delicate flavor, manufacturers of mushroom sauce prefer not to add any vinegar or other acids to this product. As a result, the sauce has a pH of 7.3. It is one of the few food products with a pH over 7. Mushroom sauce can be preserved by retorting, but it spoils rapidly after the container is opened. Table 3 shows the results obtained when vitamin K_5 was used to study its effectiveness in prolonging the storage life of opened samples or processed mushroom sauce.

It is seen that 100 p.p.m. spoilage did not occur until 21 days after incubation. This spoilage consisted of surface growth and was not extensive. The

TABLE 2

Effect of heating vitamin K_5 and sorbic acid to 200°F. for two minutes[1]

Treatment	Concentration p.p.m.	Mold growth Days incubation at 27° C. (80° F.)								
		2	3	5	7	9	12	14	15	21
Vitamin K_5, Unheated	40	—	—	—	—	—	—	—	—	—
	30	—	+	++	++	++	+++	+++	+++	
	20	+	+	++	+++	+++	+++	++++	++++	
Vitamin K_5, Heated to 200° F.	40	—	—	—	—	—	—	—	—	—
	30	—	+	+	+	++	++	+++	+++	
	20	—	+	+	++	++	+++	+++	++++	
Sorbic Acid, Unheated	400	—	—	—	—	—	—	—	—	—
	300	—	++	+++	++++					
	200	—	+	++	++++					
Sorbic Acid, Heated to 200° F.	400	—	++	+++	++++					
	300	+	+++	++++						
	200	++	+++	++++						
Control	0	+++	++++							

[1] Observations on duplicate samples.

TABLE 3

Observations of mushroom sauce treated with vitamin K_5

Parts per million of K_5 added to sauce before retorting	Spoilage Days incubation at room temperature										
	3	4	5	7	8	11	12	14	17	18	21
0	—	—	++	++++							
10	—	—	+	+++	++++						
30	—	—	—	+	++	+++	++++				
40	—	—	—	—	+	++	+++	++++			
50	—	—	—	—	—	—	—	—	+	++	+++
100	—	—	—	—	—	—	—	—	—	—	+

50 p.p.m. sample did not begin to spoil until the 17th day. This spoilage was also at the surface and did not impair the overall appearance of the jar. It was thought that the surface spoilage might have been caused by the dilution of K_5 by condensation from the lids during cooling.

Spoilage in all other samples was quite extensive and consisted of bacterial and mold growth with consequence deterioration of the product. The speed of spoilage in these samples was also greater. All of the other samples were completely spoiled before any growth occurred on the 50 and 100 p.p.m. samples.

These results also serve to demonstrate the heat stability of vitamin K_5 since the samples were processed for one hour at 250° F.

Strawberry jam. With the development of low-sugar pectin, jams can now be prepared with much less sugar for the diet-conscious consuming public. While previously relying on their high sugar content for preservation, the low-sugar jams now pose the problem of spoilage after their containers are opened. The possibility of vitamin K_5 as a preservative for jams was therefore studied and the results are shown in Table 4.

TABLE 4

Vitamin K_5 in strawberry jams

Soluble solids concentration	Vitamin K_5 p.p.m.	Mold growth Days of incubation at room temperature					
		7	8	10	13	16	21
45%	0	+	++	+++	++++	++++	++++
	10	—	+	++	++	++	+++
	20	—	—	—	—	—	—
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
55%	0	—	+	++	++	++	+++
	10	—	—	—	—	—	—
	20	—	—	—	—	—	—
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
65%	0	—	—	—	—	—	—
	10	—	—	—	—	—	—
	20	—	—	—	—	—	—
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—

It is seen that at the concentration of 20 p.p.m., vitamin K_5 effectively controlled mold growth in the low-sugar (45%) strawberry jams. For 55% jams, only 10 p.p.m. are needed. The K_5 concentrations may be reduced when the jams are stored at refrigerator temperatures.

Cottage cheese. Results obtained from the use of vitamin K_5 for the prevention of mold spoilage of cottage cheese in order to prolong the storage life are shown in Tables 5 and 6.

It is obvious that vitamin K_5 is effective in the control of mold growth in cottage cheese. Some red spots of the vitamin were observed in the cheese signifying that K_5 was not evenly distributed or completely dissolved by the mixing method. This discoloration occurred only at the spot and did not diffuse out to discolor any large areas.

Crab meat. Results obtained using vitamin K_5 as a preservative for crab meat are shown in Table 7.

The addition of vitamin K_5 to crab meat samples caused a rapid discoloration of the meat. This varied from a light pink discoloration at 10 p.p.m. to a dark red color at 100 p.p.m. The degree of discoloration was proportional to the concentration in all cases.

TABLE 5

Vitamin K_5 in cottage cheese (38°F.)

Vitamin K_5 p.p.m.	Mold growth Days of incubation at 38° F.				
	22	26	27	28	30
0	—	+	+	++	++
10	—	—	—	—	+
20	—	—	—	—	+
30	—	—	—	—	—

Note: All samples showed physical separation at the end of test.

TABLE 6

Vitamin K_5 in cottage cheese (72°F.)

Vitamin K_5 p.p.m.	Mold growth Days of incubation at 72° F.				
	2	4	5	6	8
0	+	++++			
10	—	—	—	++	++
20	—	—	—	—	+
30	—	—	—	—	+

Note: All samples showed physical separation at the end of test.

TABLE 7

Vitamin K_5 in crab meat

Treatment	Spoilage Days incubation (38–40° F.)					
	7	8	11	12	17	18
None	++++					
5% brine		++++				
Vit. K_5, 10 p.p.m.	—	—	—	—*	—*	+
Vit. K_5, 20 p.p.m.	—	—	—	—*	—*	+
Vit. K_5, 50 p.p.m.	—	—	—	—	—*	+
Vit. K_5, 100 p.p.m.	—	—	—	—	—*	+

* Samples developed an off odor which is not the same as the odor of spoiled crab meat. The observed odor was an ammonia-sulfur type.

Such a color change would prevent the use of vitamin K_5 as a preservative in this product. However, it was found that at 10 and 20 p.p.m., vitamin K_5 increased the storage life of this very perishable product by 4 days. At 50 and 100 p.p.m. concentrations, the storage life was extended from 7 days for the untreated samples to 18 days.

Spoilage of the untreated and brine samples consisted of a rapid development of a putrefactive odor. This type of spoilage was not observed in any of the K_5 treated samples. These samples developed a sulfur-like odor. This was accompanied by a slimy surface development in the 10 and 20 p.p.m. treated samples. The development of this off odor was not as marked in the 50 and 100 p.p.m. treated samples, and these samples did not develop a slimy surface during the 18-day observation period.

The results indicate that vitamin K_5 was effective in inhibiting the organisms responsible for the rapid deterioration of crab meat when stored under refrigeration. However, it permits the growth of other organisms in prolonged storage.

Frankfurter molds. Frankfurters treated with vitamin K_5 and incubated at room temperature had heavy surface mold and bacterial growth in 3 days. It was thought that the cause of rapid spoilage at room temperature was due to the poor distribution of vitamin K_5 in the samples; therefore, molds from the spoiled frankfurters were isolated and studied to determine whether they were resistant to vitamin K_5, or the methods of K_5 application have been faulty. Results are shown in Table 8.

The concentration of vitamin K_5 required to prevent growth of organisms under these conditions is above 60 p.p.m. This is higher than the 40 p.p.m. concentration required for the control of cheddar cheese mold organisms. This difference is probably due to the variety of mold and bacteria present on frankfurters, whereas spoilage of cheddar cheese is associated mainly with penicillium type molds.

Table syrup. The effect of vitamin K_5 on the mold growth of a 70% soluble solids commercial table syrup is shown in Table 9.

TABLE 8
Effect of vitamin K_5 on frankfurter molds

Vitamin K_5 p.p.m.	Mold growth Days of incubation at 80° F.				
	2	3	7	15	24
0	+++	++++			
30	++	+++	++++		
40	+	++			
50	+*	+*	+*	++*	+++*
	—	—	—	—	—
60	—	—	+*	+*	++*
			—	—	—
70	—	—	—	—	—
100	—	—	—		

* At 50 and 60 p.p.m., one set of each duplicate set was positive and one was negative.

TABLE 9
Effect of vitamin K_5 on table syrup molds

Vitamin K_5 p.p.m.	Mold growth Days of incubation at room emperature		
	30	55	85
0	+	++	++++
	—	+	++
10	—	—	—
20	—	—	—
30	—	—	—

Evidently at the high soluble solids content of 70%, the table syrup tends to preserve itself. However, one of the duplicate controls of the syrup developed a light mold growth after 30 days, and both controls had developed mold growth after 55 days. None of the vitamin K_5-treated samples had mold growth after 85 days. No color or odor defects were observed in the vitamin K_5-treated samples.

SUMMARY AND CONCLUSIONS

Vitamin K_5 has been found to be effective in prolonging the storage life of a variety of food products. It was found to be effective in inhibiting growth of organisms obtained from moldy cheddar cheese in an agar medium in concentration of 40 p.p.m. For organisms obtained from frankfurters, 60 p.p.m. was required.

Low concentrations of vitamin K_5 (10 and 20 p.p.m.) were found to prolong the storage life of crab meat, but the extreme discoloration observed would prevent commercial use for this purpose. The development of a derivative of the vitamin might be a means of circumventing this problem.

The heat stability of vitamin K_5 was demonstrated in agar streak plate tests and by the preserving action obtained in mushroom sauce after processing at 250° F. for one hour. These results would indicate that use can be made of vitamin K_5 for the preservation of food products which are not completely consumed immediately after opening the container. It is particularly important in certain military feeding systems where refrigeration is not available as well as in similar feeding situations.

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On The Color of Coffee. II.[a]

(Manuscript received May 24, 1958)

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In a previous paper, Little and Mackinney *(1)* established a procedure for measuring the relationship between the roasting temperature and and the color of roasted ground coffee. The samples for that study were prepared for us at the instance of the Coffee Brewing Institute by Mr. Fred Baselt of the American Can Company.

It became evident that further work, whether involving varietal studies, moisture differences or other variables, required a laboratory-size roaster capable of roasting samples 100 to 400 g. in size under controlled conditions, with results which could be reproduced on successive aliquots of the same sample.

The laboratory model coffee roasters of the Jabez Burns Company are designed to handle samples up to 1 lb. in size. The heating unit, whether gas or electricity, is immediately below the roasting chamber, and the contents are dumped onto a cooling tray when the operator estimates that the color of the beans indicates a finished roast.

Measurements by means of a thermocouple inserted in the chamber over the beans show that the air temperature rises steadily with time, and the roast is completed long before a constant temperature has been attained.

The use to which we needed to put the roaster was radically different from that for which it was designed.

In this paper, we describe our modification of this roaster, its instrumentation, and some preliminary results on its performance. These indicate, that with respect to color measurements, for a given load at a predetermined temperature setting, for a given time, successive roasts of the same sample will have tristimulus Y values within ±5% of the mean.

EXPERIMENTAL

Modified Jabez-Burns Roaster. As shown in Figure 1, we heat a plenum chamber, and the heated air and exhaust gases are passed through the roasting chambers. Two burners are used, with a combined output of 30,000 BTU per hr.[b] The ducts are fabricated from 20-gage sheet metal. The throttling type burners are regulated by a Robertshaw controller[c] with a sensing bulb in the input air duct. The temperature can be controlled between 300 and 500° F. ± 5° after warm up. At 400° F., there is a come-up time of approximately ½ hr.

The fan supplied with the roaster is used, forcing the air through the roaster from below. The original duct to the cooling tray is closed, so that all the air is forced through the roaster. An adjustable vent permits re-cycling of the air, arbitrarily set for about 50% recycle.

A removable steel head with a handle and a small hole with a sleeve to permit insertion of a thermocouple covers the orifice of the chamber during roasting.

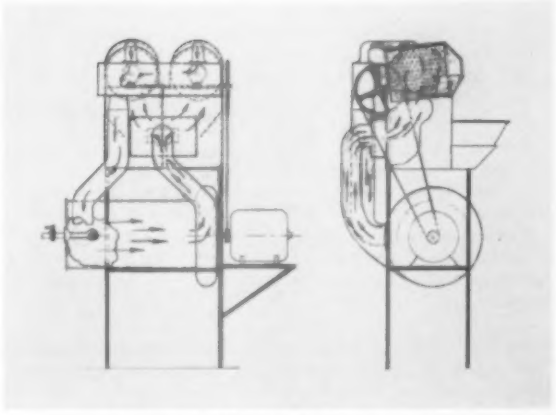

Figure 1. Modified Jabez-Burns roaster.

Temperature measurements. In operation, the chamber is brought to temperature, the head removed, the beans are quickly loaded and the head then replaced. Records of input air temperature, roaster temperature over the beans, and bean temperatures were secured in relation to a given setting of the thermostat, by setting the hot junction of the iron-constantan couple in the appropriate place. For practical purposes, the input temperature corresponds with ±3° with the thermostat, and nearly all measurements have been made of the air temperatures when the drum is empty and later when loaded. A few bean temperatures have been measured, with the hot junction inserted in a hole drilled either longitudinally or equatorially into the bean. Charts of the type shown in Figure 2 were obtained, where the course of the roast was recorded by connecting a glass-insulated iron-constantan thermocouple to a Honeywell recorder. The hot junction was inserted into the roasting chamber, and the cold junction into ice-water. The recorder was so adjusted by calibration to a standard cell that

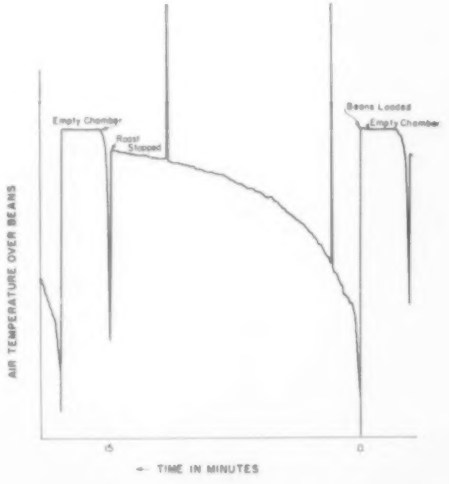

Figure 2. Time-temperature chart of a typical roast.

[a] Presented at the Eighteenth Annual Meeting of IFT, Chicago, May 28, 1958.

[b] Courtesy of Mr. D. J. Costamagna, Pacific Gas and Electric Co.

[c] Courtesy of Robertshaw-Fulton Co.

the 0 line on the paper corresponded to 250° F. (6.6 millivolts) and the 100 line, to 450° F. (12.8 millivolts). Before each run, the roaster air was brought to the maximum temperature for the setting. For each roast, the area under the curve recorded on the temperature chart was measured with a planimeter.

Coffee samples. The following green bean samples were supplied to us by the Folger Coffee Company:

(1) Santos—1957 crop
(2) Honduras—1957–58 crop, described as good wash
(3) Guatemala—1957–58 crop, described as prime
(4) Ociru—1957 crop from Africa
(5) Bani—from Dominican Republic, described as good wash to prime
(6) Robusta

Grinding of samples. The roasted samples were passed through a commercial grinder (Hobart Manufacturing Company) set to fine (vacuum pot) grind, at least 3 times to insure as uniformly a fine grind as possible.

Color measurements. Reflectance measurements were made on a Colormaster Differential Colorimeter (Manufacturers Engineering and Equipment Corporation) as previously described *(1)*.

Procedures. To determine the effect of source and varietal differences on the development of color during the roasting cycle and to establish reproducibility of results under standardized conditions, 150 g. samples of each of the 6 varieties of beans were roasted in duplicate for 15 minutes at thermostat settings of 325, 350, 375, 400 and 425° F.

We also made preliminary measurements of bean temperatures during the roasting cycle. The Santos variety was arbitrarily chosen for this series of roasts.

Our first approach to the study of internal bean temperatures involved essentially a repetition of the previously described experiment, (i.e. a constant charge of 150 g., roasting time, 15 minutes, temperature of roast varied by setting the thermostat to 325, 350, 375, 400 and 425° F.). However, with the thermocouple inserted into a bean, a measure of the internal temperature of the bean rather than that of the air over the beans should be recorded.

In the second experiment, the input temperature and time of roast were held constant (i.e., thermostat set to 400° F. and time of roast, 15 minutes), while the charge was varied. Duplicate runs of 100, 150, 200 and 300 gram loads were made. For each pair, the air temperature over the beans was recorded in the one case, while the internal bean temperature was recorded in the other.

RESULTS AND DISCUSSION

In Table 1, data showing variations in Y value and areas under the time-temperature curves with source and degree of roast are summarized. Average values for the duplicate runs are listed, as agreement to within a maximum of approximately ±5% was obtained in each case.

These results indicate that significant differences in color development do occur, depending on source or variety. For example, the Y values of Robusta and Santos were practically identical at the 325° F. input roast. However, at 425° F., the Robusta sample does not produce a "finished" roast, whereas the Y value of the Santos sample indicates an acceptable commercial roast.

We then plotted the change in Y value with increase in temperature versus the change in area with increase in temperature with reference to the 350° F. roasts for the 6 different samples and thus obtained the series of lines shown in Figure 3.

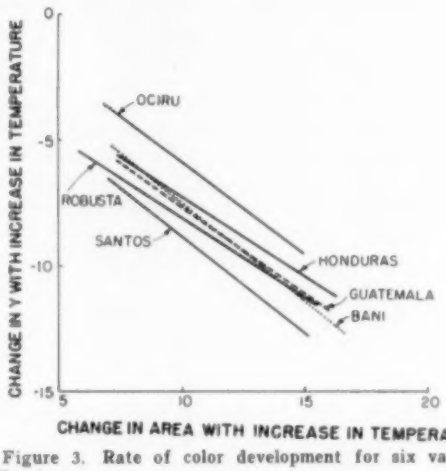

Figure 3. Rate of color development for six varieties of coffee bean.

Estimates of the slopes of the lines for the 6 varieties indicate that the Santos, Guatemala, Ociru and Bani varieties show a change in Y of approximately −0.8 per unit change in area, while the Honduras and Robusta beans show change in Y of approximately −0.7 and −0.6, respectively, per unit change in area. Thus, while the end results differ, color development, as measured by the Y value, is proceeding at a fairly constant rate within the limits of the temperature range studied for most of the 6 varieties. Evaluation of the significance of this cannot be made until a more extensive study is completed.

When the thermocouple was inserted into a bean to determine internal bean temperature during the roasting cycle, an initial lag period in temperature come-up was noted varying from less than one minute up to two minutes. In all instances the area under the curve was less than that of the corresponding roast when the air temperature over the beans was being recorded.

TABLE 1

Variation in lightness (Y) and area under curve (A) with source and degree of roast

Source or variety of beans	Thermostat set at 325° F.		Thermostat set at 350° F.		Thermostat set at 375° F.		Thermostat set at 400° F.		Thermostat set at 425° F.	
	Y	A	Y	A	Y	A	Y	A	Y	A
Santos	24.4	21.0	18.8	28.5	12.2	35.4	8.4	40.4	6.0	43.6
Honduras	20.8	21.4	17.6	27.5	12.0	35.0	8.2	39.9	6.4	43.8
Guatemala	23.6	22.0	19.8	27.6	14.0	35.0	8.1	38.4	7.6	43.4
Ociru	25.5	21.7	16.6	28.0	13.1	34.8	10.0	38.6	7.1	43.1
Bani	25.6	22.5	21.4	26.6	16.2	33.8	13.2	38.3	8.5	43.2
Robusta	24.1	21.2	21.2	27.3	15.8	33.2	12.5	38.4	9.6	42.8

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Results of the experiment designed to measure internal bean temperature when load and time are held constant and temperature is varied are summarized in Table 2.

It is apparent that closer agreement is achieved when two successive runs are made when the air temperature is recorded rather than the bean temperature. Whether the bean is bored equatorially or longitudinally, the size of the bean, the depth of the hole, are all variables which may contribute to inconsistencies.

The study of the effect of load at constant input temperature and time on the bean temperature, air temperature, and Y value also showed qualitatively similar decreases in area and maximum temperature of roast when measurements were recorded with the thermocouple inserted in a bean. In Table 3, the results of this experiment are listed. From the data in Table 3, Figure 4 was constructed.

TABLE 2

Comparison of internal bean temperatures with air temperatures for Santos beans Load constant—temperature varied

Thermostat setting °F.	Bean temperature			Air temperature		
	Area	Max. temp. °F.	Y	Area	Max. temp. °F.	Y
325 (E)	16.8	308	23.3	(1) 20.4	311	24.6
(L)	18.2	307	24.2	(2) 21.7	312	24.3
350 (E)	24.5	333	19.3	(1) 28.6	339	18.9
(L)	20.0	324	18.1	(2) 28.4	339	18.6
375 (E)	26.0	351	12.4	(1) 36.9	363	11.9
(L)	28.8	353	11.9	(2) 34.0	362	12.6
400 (E)	30.0	371	9.2	(1) 40.1	388	8.5
(L)	28.6	367	8.2	(2) 40.6	388	8.4
425 (E)	35.7	395	4.8	(1) 43.5	397	5.9
(L)	37.4	394	4.8	(2) 43.7	398	6.1

(E) bean bored equatorially.
(L) bean bored longitudinally.
(1 and 2) duplicate runs.

TABLE 3

Effect of load on temperature of roast and Y value at constant input temperature (400°F.) for Santos beans

Load (grams)	Bean temperature			Air temperature		
	Max. temp. °F.	Area	Y	Max. temp. °F.	Area	Y
100	378	37.4	6.8	380	39.7	7.0
150	374	35.8	7.9	376	37.1	8.0
200	368	30.7	9.6	372	32.1	9.6
300	352	24.7	12.5	367	27.0	12.1

From Figure 4, it is readily apparent that the size of load markedly affects the development of color at constant thermostat setting, and Y value varies inversely with area at 400° F. input temperature.

Quantitative discrepancies which may be noted on comparing non-consecutive runs of the same composition may be due to one or more of several variables which warrant further attention. Mention has already been made of the possibility of differences in the physical chearacteristics of the bean contributing to variation in temperature recordings. The ability to reproduce the thermostat setting or to place the thermocouple in the same position each time may require greater precision. It is possible that several thermocouples in series or in parallel should be inserted in the chamber in order to get a better estimate of the average air temperature.

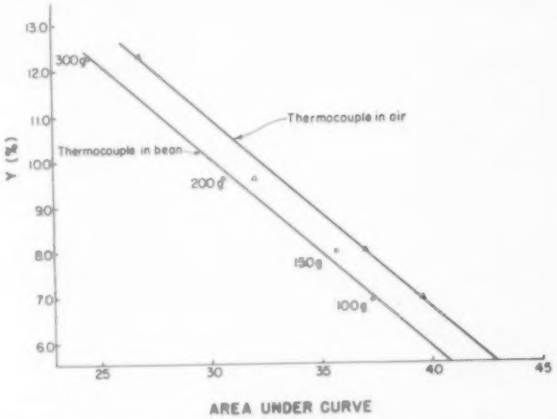

Figure 4. Effect of variation in load on color development for Santos bean.

At present, we are able to control conditions so that when two successive roasts of aliquots of the same sample are run, the resulting Y value can be predicted within ±5%.

SUMMARY

A modified Jabez-Burns laboratory roaster designed for constant input temperature has been described.

A series of roasts under controlled conditions for six varieties of coffee indicate that the rate of color development is relatively constant during the latter part of the roasting cycle for most of the varieties studied.

Preliminary results on the measurement of the internal temperature of the bean during the roasting cycle are presented.

Effect of load on development of color at constant input temperature and time of roast is discussed. The results indicate that a linear relation exists between area and Y value when the load is varied at constant input temperature.

Acknowledgment

A grant-in-aid from the Coffee Brewing Institute, Inc. is gratefully acknowledged.

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A Sampling Method for Household Surveys

II. Panel Characteristics and Their Relation to Usage of Wine

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(Manuscript received May 3, 1958)

IN A PRECEDING PAPER (1), a sampling method was described for wine surveys. Problems of sampling were discussed and a procedure devised to obtain a random sample of families of certain predetermined characteristics. Two studies were made, one in Woodland and the other in Sacramento, California. Results reported in this paper are those from the Sacramento study which furnished a panel size sufficient to evaluate certain minority groups.

The primary purpose of this study was to determine which panel characteristics correlated with wine usage. A secondary purpose was to measure the relationship between panel characteristics and the preference expressed between two wines of different sweetness.

The panel consisted of all those adults willing to participate, from families whose yearly income was between $3,000 and $10,000. The recruited panel numbered 714 families (1386 adults) of which 273 were regular users of wine. For the participating panel a reduction in regular users was made to 150 families to fulfill a requirement that only 25% of the panel would consist of regular users.

EXPERIMENTAL PROCEDURE

One bottle each of a 1% and 3% sugar Rosé table wine were delivered to each family together with 2 questionnaires for each participating adult member of the household. The first questionnaire asked for the participant's age, frequency of use of wine, parents' usage of wine, amount and type of wine on hand, educational level, occupation and yearly family income. The second questionnaire was used to record the panel member's preference between the 2 wines, and his reaction to purchase of the wines. Participants were instructed to use the wines as they wished within the following 7 days, and then complete the questionnaires and mail them to the survey office.

RESULTS AND DISCUSSION

Relationship between age of individual and usage of wine. It was found that the percentage of regular users of wine increases with age as is evidenced by examination of the data in Table 1. Also, there is a higher percentage in the 21–30 age group who never use wine. These findings indicate that regular usage of wine requires familiarization with the product over an extended period of time.

TABLE 1
Comparison of wine usage and age for recruited panel

Usage category[1]	Age				
	21–30	31–40	41–50	51–60	Over 60
	%	%	%	%	%
1	24.8	37.4	42.3	44.1	54.8
2	31.5	29.6	31.4	20.4	18.3
3	31.5	26.7	20.7	28.3	19.6
4	12.2	6.3	5.6	7.2	7.3

[1] Category 1—regular usage, 1 or more times a week. Category 2—irregular usage, 1 to 3 times a month. Category 3—infrequent usage, 1 to 5 times a year. Category 4—never use wine.

Relationship between number of adults per family and wine usage. As shown in Table 2 there was a significantly lower percentage of one-adult families who were regular users of wine. The data show that this was true of all 4 socioeconomic areas, and that this could not be ascribed to income level or social differences. Evidently regular wine usage is closely related to conviviality in the home.

Usage of wine versus socioeconomic area. As seen in Table 3 there were no large differences in wine consuming habits between the 4 income groups. Although Area C had a smaller percentage of regular users this could be accounted for by its lower age level.

TABLE 3
Comparison of wine usage and socioeconomic area

Category of usage[2]	Socioeconomic area[1]			
	A	B	C	D
	%	%	%	%
1	41.2	40.8	33.3	42.0
2	29.6	30.0	26.7	23.9
3	22.3	22.4	31.2	29.5
4	6.9	6.8	8.8	4.6

[1] Areas A, B, C, D refer to high, upper middle, lower middle and low income, respectively.
[2] Category 1—regular usage, 1 or more times a week. Category 2—irregular usage, 1 to 3 times a month. Category 3—infrequent usage, 1 to 5 times a year. Category 4—never use wine.

TABLE 2
Comparison of wine usage by socioeconomic area and adults per family for the recruited panel

Wine usage[2]	Socioeconomic area[1]							
	A		B		C		D	
	Adults per family		Adults per family		Adults per family		Adults per family	
	1	2 or more	1	2 or more	1	2 or more	1	2 or more
	%	%	%	%	%	%	%	%
Category I	14	54	8	45	10	39	18	46
Category II	86	46	92	55	90	61	82	54

[1] Areas A, B, C, D refer to high, upper middle, lower middle and low income respectively.
[2] Category I, regular wine usage. Category II, irregular, infrequent and never users of wine.

TABLE 4

Comparison of wine usage by sex and educational level

Wine usage[1]	Male	Female	Total
Category I	%	%	%
By educational level			
Grammer school only	23	15	20
High school	61	61	61
College graduate	16	24	19
Category II			
By educational level			
Grammer school only	25	23	24
High school	56	65	60
College graduate	19	12	16

[1] Category I, regular wine user. Category II, irregular, infrequent and never user of wine.

Usage of wine versus educational level. The only significant difference shown in Table 4 is in the usage of wine by women who are college graduates. It is suggested that the social impact of a college education is greater on women; they are more likely to have a concern with social and cultural matters, whereas men will have primary interest in economic matters. As the use of wine is associated with gracious living there would be a pronounced tendency for these women to be regular users.

Wine usage by occupation. Of the occupations listed in Table 5 only that of housewife shows a significant difference in wine usage. The reason for this difference is given in Table 6, where it is seen that the percentage of housewives who are college graduates is much higher among the regular users.

TABLE 5

Wine usage by occupation

	Wine usage[1]	
	Category I	Category II
	%	%
Professional or executive	18	14
Farmer or rancher	1	0
Owner—shop or service	5	3
White collar worker	18	19
Skilled craftsman	19	16
Laborer (farm, factory)	1	3
Housewife	29	37
Other (sales, driver, military)	9	8

[1] Category I, regular wine usage. Category II, irregular, infrequent and never user of wine.

TABLE 6

Wine usage of housewives by educational level

Educational level	Wine usage[1]	
	Category I	Category II
	%	%
Grammar school only	21	28
High school	65	64
College graduate	18	8

[1] Category I, regular wine user. Category II, irregular, infrequent or never use wine.

Parental influence on panel usage of wine. Table 7 shows that the panel usage of wine was influenced by the parental usage during the time that the panel member resided in the parental home. The high percentage of panel regular users (27%) who came from homes where wine was used regularly is particularly striking in view of the fact that all the panel members from regular usage families constituted only 14% of the total panel. However, there appears to be some extra-familial influences involved since 35% of the panel regular users came from families who had never used wine. This suggests the effect of promotional and wine-education programs.

Preference between two test wines. The preference between the 2 test wines is given in Table 8. There was a definite preference demonstrated for the 3% sugar wine by all categories of wine usage. It is interesting that a high degree of no-preference (52%) was expressed by those who never use wine; this is due to the fact that many of these individuals disliked both wines.

No differences of significance were noted in preference between the socioeconomic areas (Table 9). This was surprising as the higher income groups are generally supposed to have a greater knowledge of food and drink. Traditionally, the mark of a cultured person has been his or her appreciation of the low sugar wines as an integral part of enjoyable dining. Our finding seems to confirm the widely held opinion that the general public in the United States knows little about wine.

Table 10 gives preference data for those who stated that they would buy either or both of the test wines. With increasing age there was a trend toward an increasing preference for the sweeter wine and a decreasing preference for the less sweet wine.

TABLE 7

Comparison of panel's present usage with parental usage of wine

Parental usage[1]	Panel's present usage of wine[1]				Percentage of whole panel
	1	2	3	4	
	%	%	%	%	
1	27	13	8	6	14
2	13	16	5	3	11
3	25	33	32	13	29
4	35	38	55	78	46

[1] Category 1—regular, 1 or more times a week. Category 2—irregular, 1 to 3 times a month. Category 3—infrequent, 1 to 5 times a year. Category 4—never use wine.

TABLE 8

Preference between two test wines by category of usage

	Panel wine usage by category[1]			
	1	2	3	4
	%	%	%	%
Prefer 3% Rosé	63	60	55	34
Prefer 1% Rosé	24	27	20	14
No preference	13	13	25	52

[1] Category 1—regular, 1 or more times a week. Category 2—irregular, 1 to 3 times a month. Category 3—infrequent, 1 to 5 times a year. Category 4—never use wine.

TABLE 9

Preference between test wines by socioeconomic area

	Socioeconomic area[1]			
	A	B	C	D
	%	%	%	%
Preference for 3% Rosé	56	58	57	53
Preference for 1% Rosé	22	24	23	25
No preference	22	18	20	22

[1] Area A—high income. Area B—upper middle income. Area C—lower middle income. Area D—low income.

TABLE 10

Preference between test wines by panel age group

	Age group				
	21–30	31–40	41–50	51–60	Over 60
	%	%	%	%	%
Preference for 3% Rosé	56	64	67	67	69
Preference for 1% Rosé	32	27	23	20	18
No preference	10	9	10	13	13

SUMMARY

Employing a stratified, random sample of Sacramento households fulfilling the requirements of $3,000–$10,000 yearly family income and willing to participate on a wine-tasting panel, a number of

characteristics were noted in their relation to wine usage.

General usage of wine increased with age of the individual, implying that wine usage requires familiarzation over an extended period of time. Usage of wine was affected by the number of adults in the family; less usage was demonstrated by one-adult families. Socioeconomic area and wine-consuming habits were not related. The educational level did not affect the usage of wine by men, but a greater proportion of regular users among women were college graduates, which suggests that social and cultural concerns attendant on higher education have a greater impact on women than on men. Both parental and extrafamilial influences were shown to affect wine usage.

There was a definite preference for 3% sugar against 1% Rosé test wine; this was shown by all categories of wine usage and increased with age group of the test panel. The preference was essentially the same for all socioeconomic areas.

Acknowledgment

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Preparation of New and Improved Products From Eastern (Dry-Type) Sweetpotatoes: Chips, Dice, Julienne Strips, and Frozen French Fries[a]

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(Manuscript received January 29, 1958)

Four pre-cooked, dehydrated sweetpotato products i.e. chips, julienne strips, dice and frozen French fries, have been prepared from eastern (dry-type) sweetpotatoes. Several varieties of moist-type sweetpotatoes were also used as raw material in this study. These products were produced by the French-frying process previously employed for the preparation of beet, carrot and parsnip chips, and pea and lima bean nuggets *(3)*. Sweetpotato chips from yams, or moist type tubers, have been prepared by other investigators *(2, 4, 5, 6)*.

This paper presents methods of preparation, yields, oil and moisture contents, stability characteristics, and potential uses of the four types of products. Novel convenience food items may provide some resistance to the decreasing consumption of sweetpotatoes which declined from an annual domestic per capita consumption of 19.4 pounds in 1939 to 8.9 pounds in 1955 *(1)*.

EXPERIMENTAL PROCEDURES AND RESULTS

Varieties. Seven varieties of sweetpotatoes were used for the preparation of chips: Jersey Orange (Orlis), Maryland Golden, Red Jersey, Yellow Jersey as dry-types and Oklahoma Yam No. 24 (Allgold), Oklahoma Yam (strain unknown) and Louisiana Coon Yam as moist-types. Our use of the terms, dry-type, as compared to the moist-type, is based on the classification of Thompson *(7)*. These terms refer to the texture of the cooked product which is dry and mealy for the dry-types and moist, soft and usually sweet for the moist-types. The original moisture content of the dry-types may actually be higher than that of the moist-types. The first 5 varieties were grown in New Jersey or Maryland and the latter two varieties were southern grown. Julienne strips and diced sweets were made only from the Maryland Golden variety and frozen French fries were prepared from Jersey Orange, Maryland Golden, Yellow Jersey and Oklahoma No. 24.

Equipment. Sweetpotatoes were sliced to dimensions specified below with a standard rotary knife slicer, Model 20,[c] manufactured by the Eagle Machine and Tool Company, Springfield,

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

[b] Eastern Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture.

Ohio.[5] This cutter was easily adjustable to slice at any thickness but the adjustment had to be checked with a micrometer gauging of the cut slice.

The deep fat fryer used in this study was a Hotpoint Fry Kettle Model HK3[6] having a capacity of 15 pounds of frying oil. This model is available with either one large or two small baskets for holding the food product. Both sizes were useful for different size batches. In most of this work one-half to one- pound lots were fried in the large one. The Calrod[6] heater of this fryer quickly brought the temperature of the hot oil to the thermostat setting required for each experiment even with the larger quantity of vegetable.

Frying medium. Evaluation tests with different types of frying media have not been made to date. As in previous studies on vegetable chips *(3)*, a commercially available modified coconut oil was used because of its high stability and its failure to harden at room temperature on the surface of the sweetpotato products. Other oils which approximate these characteristics should be equally satisfactory.

Preparation of sweetpotato products. Sweetpotatoes were carefully washed and pared by hand without any pretreatment. Pared roots were trimmed slightly to even them for better slicing or cutting for chips, dice, or julienne pieces. Peeling losses amounted to about 18% of the original weight for good quality field run roots of the Jersey Orange or Maryland Golden varieties.

The Oklahoma No. 24 yam was often so large it was cut in half and handled as two roots. The sweetpotatoes of 2–3 inch diameter, such as found in the 3 varieties named immediately above, gave the best pared yields and the most uniform pieces for dice, julienne and French fries. Smaller diameter roots were better for chips since there was less folding of the slices during frying.

Sweetpotato chips were sliced at $\frac{1}{16}$ and $\frac{1}{32}$ inch thicknesses for experimental work with the 7 different varieties. They were fried at 275° F. for varying periods of time from 3–5 minutes. The slices were not blanched or soaked prior to frying. After cooking, the chips were drained and salted with flake salt or left unsalted. They were stored in the dark in glass bottles with tight lids.

Julienne strips were prepared by slicing at $\frac{1}{16}$ inch followed by cutting of the slices the long way to give strips of $\frac{1}{16}$ x $\frac{1}{16}$ inch cross section about 2 inches long. For dice pieces these 2 inch strips were again cut to give cubes $\frac{1}{16}$ inch on a side. Larger strips were prepared for preliminary trials and these were likewise cut for cubes of $\frac{1}{8}$–$\frac{3}{16}$ inch size.

French fries were prepared by first trimming the pared roots to approximately a square cross section followed by cutting with a standard restaurant size white potato French fry cutter to about $\frac{7}{16}$ inch cross section. On frying, these gave pieces of $\frac{3}{8}$ inch cross section.

[5] Mention of trade names does not imply endorsement by the United States Department of Agriculture over similar products not mentioned.

Combined paring and trimming losses for the preparation of the French fries are somewhat greater than those for the chips, dice and julienne strips due to the necessity for squaring the roots before cutting. The average loss for Jersey Orange sweetpotatoes was 38.8% of the unpared weight, for Maryland Golden, 31%, and for Oklahoma No. 24 (Allgold), 37%.

Cut pieces were cooked in the frying oil at 275° F. for varying periods from 3–7 minutes for the trial experiments. Fried pieces were drained and frozen without salting at −22° F. They were kept at this temperature until needed. For use the frozen pieces were placed in a gas oven at 350° F. for 10 or 15 minutes depending upon the frying time.

Since the French fries as they come from the hot oil are only partially cooked before freezing, the oven warming serves not only to thaw the frozen pieces and bring them to temperature, it also cooks and browns the pieces for better taste and appearance. For example, satisfactory products could be made at 4 minutes frying time with 15 minutes warming of the frozen pieces and 6 minutes frying time with 10 minutes warming.

RESULTS AND DISCUSSION

Table 1 provides data on the sweetpotato chips. The moisture content of the raw material varies with the conditions at the time of harvesting and the curing and storage conditions. No attempt has been made to follow the exact history of each batch of potatoes since it was necessary to obtain certain varieties through a wholesale produce house. In general, in this area, newly harvested potatoes are cured for wound healing for about 10 days at 80°–90° F. and stored in houses kept as close as possible to 55° F. We have found that the quality of the stored sweetpotatoes remains high during the winter and early spring months but becomes lower in those purchased in late April and early May.

Chips made from $\frac{1}{16}$ inch slices were better from a structural standpoint but with most varieties they tended to be a little tough and chewy. Chips sliced at $\frac{1}{32}$ inch were generally preferred by most tasters for ease of eating and general appearance. Many of these thinner chips were wrinkled and folded, and might present problems for use with dips. On the other hand, their greater bulkiness would make a better-filled and more attractive package.

Chips prepared from Jersey Orange and Maryland Golden sweetpotatoes were rated highest in color and texture by the consumer-type taste panels to whom they were submitted. The deep orange color was preferred when compared with the lighter colored chips

TABLE 1

Preparation of chips from dry and moist type (yam) sweetpotatoes[1]
(French fried at 275° F.)

Variety	Area grown	Moisture fresh	Thickness of slice	Frying time	Oil content	Yield (based on pared and trimmed roots)
		%	*inches*	*min.*	%	%
Dry-types						
Jersey Orange	Maryland and New Jersey	72.6	$\frac{1}{16}$	3½	30.7	38.5
Jersey Orange		78.8	$\frac{1}{32}$	3½	39.8	37.0
Jersey Red	New Jersey	72.4	$\frac{1}{16}$	3¼	28.6	38.4
Jersey Yellow	New Jersey	72.2	$\frac{1}{32}$	3½	.....	50.0
Maryland Golden	Maryland	76.8	$\frac{1}{32}$	3¼	41.9	40.4
Moist-types						
Oklahoma Yam	New Jersey	62.8	$\frac{1}{16}$	3	26.4	49.7
Oklahoma No. 24 (Allgold)	New Jersey	75.6	$\frac{1}{32}$	3½	35.6	39.2
Louisiana Yam	South	65.2	$\frac{1}{16}$	3½	28.2	42.3

[1] Average data from 4–6 replicates prepared from one lot of each variety. Data are representative of values obtained in numerous preliminary experiments.

resulting from the frying of the Jersey Red and Jersey Yellow varieties. The color of chips prepared from the yam types was satisfactory but the crunchy nature of the dry-types was preferred to the harder, horny texture resulting from the frying of the yams under the conditions used in our studies.

Data on the 4 types of products are given in Table 2. Only one variety, the Maryland Golden, was prepared in these forms but it is probable that the Jersey Orange variety would have been equally satisfactory. The completely fried chips, julienne strips and dice have very low moistures whereas the French fries still contain about 46% moisture. In the diced products the 1/16–3/32 inch cubes contained 2.7% moisture with 5 minutes cooking, whereas the 1/8–3/16 inch cubes had 2.1% higher moisture with 6 minutes cooking. This slight difference in moisture content was actually reflected in the crispness of the pieces with the larger cubes being slightly chewy.

TABLE 2
Data on sweetpotato products deep-fat fried at 275° F.[1]
(Maryland Golden Variety)

Products	Moisture		Frying time	Oil content	Yield (based on pared and trimmed roots)
	Fresh	After cooking			
	%	%	*min.*	%	%
Chips (1/32" slice)	76.4	3.3	3¼	41.9	40.4
Julienne strips (1/16" x 1/16")[*]	76.4	2.7	5	37.3	38.4
Dice (1/8"–3/16" cube)	76.4	4.8	6	34.8	32.3
Dice (1/16"–3/32" cube)	76.4	2.7	5	41.9	41.6
Frozen French Fries (⅜" x ⅜")[*]	76.4	47.2	4	11.8	55.4

[*] Length variable (2–3½").
[1] Average data from a minimum of 3 frying experiments from one 50 pound lot. Data are representative of values obtained in numerous preliminary experiments.

The oil absorption of the larger cubes was also somewhat lower than that of the thinner cubes, chips or strips and, as a result, the yield was lower.

Moisture, oil content, and yield relationships are quite different in the French fries than in the chips, julienne and diced products. With the higher moisture content, due to slower removal of water from the large pieces, less oil is taken up but the yield of the partially cooked product is greater. Oven heating of the frozen French fried pieces of 47% moisture content brings about a further reduction of moisture to a value of 37%. The yield of the finished product, after oven-warming, with its lower moisture content would amount to 48% instead of 55% for the Maryland Golden sweetpotato listed in Tables 2 and 3.

Data for two additional varieties of sweetpotatoes used for the preparation of French fries are given in Table 3. The data on the Maryland Golden variety as shown in Table 2 are included for comparison as are the data for sweetpotato chips of all 3 varieties. The moisture contents of the 3 varieties of French fries after frying are within 2% and the yields are within the same limits. The oil content of the Oklahoma No. 24 (Allgold) yam variety is lower than that of the other two varieties.

Yields of sweetpotato products. One bushel of sweetpotatoes has an average weight of 55 pounds (la) but after curing and storage this weight may be lower. Based on the 55 pounds weight, a bushel of sweetpotatoes would yield 45.1 pounds of pared roots when the average paring and trimming loss for chips, dice, and julienne strips is 18%.

The average yield of fried chips, dice, or julienne for the 3 varieties, Jersey Orange, Maryland Golden, and Oklahoma No. 24 (Allgold), based on the pared and trimmed weights is 38.9% or 17.5 pounds of chips from one bushel.

The average yield of chips on the 7 varieties shown in Table 1 was 41.9% or 18.9 pounds from a bushel.

Yields of pared and trimmed pieces for French frying are somewhat less because of the greater trimming losses. A 55-pound bushel of sweetpotatoes of the 3 varieties listed in Table 3 would yield an average of 35.4 pounds of pared and trimmed roots. The overall yield of the fried product is a little higher because of the higher moisture content. This was an average of 56.4% for the three varieties which would give an average of 20 pounds of French fries/bushel.

Evaluation of deep-fat fried sweetpotato products. Chips were tested for texture, color and flavor by consumer-type taste panels. Texture was rated as either crisp or crunchy, or tough and chewy. Flavor was to a great extent a matter of sweetness and similarity to that of a baked sweetpotato. Good texture ratings

TABLE 3
Preparation of chips and frozen french fries from three sweetpotato varieties for storage studies[1]
(Fried at 275° F.)

Variety and product	Moisture		Thickness	Frying time	Oil content	Yield (based on pared and trimmed roots)
	Fresh	After frying				
	%	%	*inches*	*min.*	%	%
Jersey Orange						
Chips	78.8	.....	1/32 slice	3½	39.8	37.0
French Fries	78.8	45.2	⅜ x ⅜[*]	4	14.4	57.4
Maryland Golden						
Chips	76.8	.....	1/32 slice	3¼	41.9	40.4
French Fries	76.8	47.2	⅜ x ⅜[*]	4	11.8	55.4
Oklahoma No. 24 (Allgold)						
Chips	75.6	.....	1/32 slice	3½	35.6	39.2
French Fries	75.6	45.8	⅜ x ⅜[*]	4	10.03	56.4

[*] Length variable (2–3½").
[1] Average data of numerous replicates prepared from 50 pound lots of each variety.

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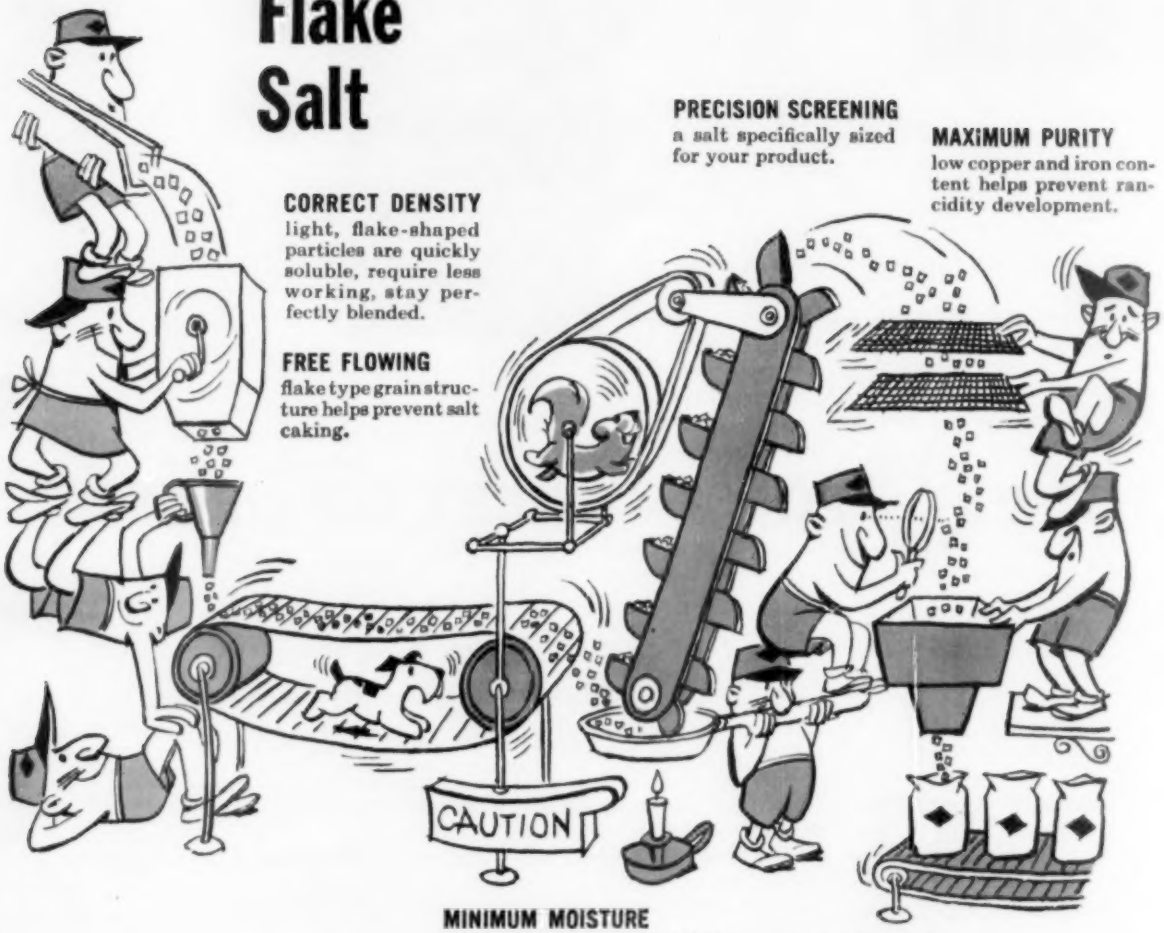

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were assigned to Jersey Orange and Maryland Golden Chips with Oklahoma No. 24 (Allgold) chips a close second. These chips were satisfactory from the color standpoint having an attractive bright orange appearance. Chips made from Jersey Red and Jersey Yellow varieties were not as crisp and they were a pale yellow, less attractive color. Chips made from Oklahoma (red root) yams, and Louisiana Coon yams were likewise tougher and more chewy. They had a deeper orange color and a duller finish. Taste preference for the different chips was greatly influenced by their relative sweetness. As in the tasting of other vegetable chips, some panel members felt that all except the bland Jersey Red and Jersey Yellow chips were too sweet. When asked to rate the flavor, other than sweetness, the Jersey Orange and Maryland Golden were preferred.

Julienne strips and sweetpotato dice were acceptable to all who liked sweetpotato chips.

French fried sweetpotatoes were rated for preference of the 15-minute oven-warmed product after 3, 4, 5, 6, and 7 minutes of deep-fat frying and freezing. The 4-minute product was considered most satisfactory. Six-minute frying with 10-minute warming was also well liked, particularly if a more crisp toasted product was preferred by the taster.

The laboratory taste panel also rated the 4-minute French fries made from Maryland Golden, Jersey Orange and Oklahoma No. 24 (Allgold) varieties after a storage period of 5 months at −22° F. A sample of Maryland Golden frozen French fries, freshly prepared from stored roots was also included in this test. All three varieties were rated satisfactory from the taste and appearance standpoint. Maryland Golden was rated highest in taste preference with Jersey Orange next. Oklahoma No. 24 (Allgold) was rated highest in color and general appearance.

When the two samples of Maryland Golden were evaluated, definite preference was shown by the panel for the French fries prepared in November and held in frozen storage compared with those prepared in April from sweetpotatoes that had been stored in commercial storage houses from harvest time in October to early April. Both texture and taste in the latter sample were considered inferior to the frozen product prepared in late fall. It is probable that certain varieties might remain in better condition in storage houses and that the original condition of the sweetpotato and its curing might influence the quality of the final product. Apparently it would be necessary in the commercial scale preparation of frozen French fried sweetpotatoes to obtain these either in the late fall and early winter months or test each lot for quality in the early spring months.

In April and May over 130 visitors to the laboratory were served frozen French fries made from the Jersey Orange and Maryland Golden sweetpotatoes prepared in November. About 70% of the tasters indicated they would purchase this product if it were commercially available.

SUMMARY

Four sweetpotato products have been successfully prepared from dry-type sweetpotatoes grown in the northeast section of the country. These are deep-fat fried chips, dice, julienne strips and French fries.

Chips, dice and julienne strips prepared from Jersey Orange (Orlis) and Maryland Golden varieties gave crisp, well-colored tasty products without prior blanching or soaking. These varieties likewise made excellent French fries for the preparation of frozen packs for home consumption. One yam variety, Oklahoma No. 24 (Allgold) grown in the Northeast was also used for the preparation of acceptable French fries.

Data on conditions of cooking, moisture and oil contents of the finished products, and yields based on the pared and trimmed roots and one the original sweetpotato were obtained.

A discussion of taste panel evaluation of the four products is also included.

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Relation of Sample Size and Temperature to Volumetric Expansion of Popcorn*

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(Manuscript received April 18, 1958)

TEMPERATURE has long been recognized as one of the important factors in popping samples of popcorn. Hartley and Willier *(5)* stated that slow or uneven application of heat resulted in waste from decreased popping volume. Stewart *(7)* suggested that either too much or too little heat would spoil the pop. However, he found no advantage in "pre-heating" the popper used and relied on time consumed in popping to establish the proper temperature. Brunson and Smith *(1)* pointed out that temperature was one of the three major conditions affecting popping expansion. He stated that under most conditions, temperatures that initiate popping in 60 to 90 seconds gave best results. Eldredge and Lyerly *(2)* found that with below optimum temperature corn dried somewhat before popping and with above optimum temperature, some kernels scorched and gave lower popping volume. Eldredge *(3)* reported that when using a 3-ounce cup, the highest volume was obtained by placing seasoning and popcorn at room temperature into the popper adjusted to operate between a low of 340° F. and a high of 460° F. Thomas *(8)*, in popping individual ear samples, found that a lower temperature than optimum for 3-ounce samples was necessary to satisfactorily pop small samples. Huelsen and Bemis *(6)* showed that an increase in volume could be obtained by preheating the popper to temperatures as high as 550° F. Eldredge and Thomas *(4)* found significant interactions between temperature and hybrids, temperature and moisture content and between temperature and sample size. However, highest volumes generally were obtained with the 6-ounce sample when the popper was adjusted to heat to 510° F. when the thermostat cut off and corn was added at that time. With a 3-ounce sample, the best volumes were obtained when the popper was adjusted to approximately 400° F. when the thermostat cut off and corn was added at that time. Higher temperatures with the 3-ounce sample resulted in much more rapid popping but drastically reduced the popping volumes. A number of the above studies *(3, 4, 6, 8)* were made using a similar popping machine.

It is recognized that optimum temperatures on a particular machine necessarily would not be the same as for other machines or under different conditions for the same machine. The reservoir of heat contained by different size and weight of popper bowls would be one factor to be considered. In addition, voltage fluctuations would have an effect on the rapidity of heating of the popper after raw corn and oil are added. Also, studies at this station have shown that the temperature of the raw corn has an effect on the time required to bring corn to popping temperature and on the popping expansion. Accordingly, it might be expected that the amount of heat required to bring varying size samples of corn to optimum expansion could be acquired by different temperature control settings on a popping machine or by allowing the popper to heat to different levels of temperature before putting the raw corn and oil into the bowl.

Since there is a considerable difference in reported optimum temperatures and since more rapid advances in crop breeding research with popcorn might be accomplished if the popping volume of individual ears could be determined with more accuracy, an attempt was made to determine proper temperatures for different size samples with a specific popping machine. In addition, a pyrometric control of heat was compared with thermostatic control.

MATERIALS AND METHODS

The popper used in this study was manufactured by C. Cretors & Company of Chicago, Illinois, and has been accepted as the official volume tester (O. V. T.) by the Popcorn Processors Association. The popper previously has been described by Huelsen and Bemis *(6)*. The electric current used as a source of heat on the machine is controlled by a thermostat.

A Proportioning Pyrometric Control manufactured by West Instrument Corporation, Chicago, Illinois was used to control electric current during part of this experiment to compare accuracy of popping with thermostatic control.

In order to place the popper at the same temperature level with each of the two controls, it was necessary to fill the popper bowl with oil and adjust each control according to the temperature of the oil. Because of the difficulty of adjusting the thermostat rapidly, individual temperature levels were first established with it and then the pyrometric control was adjusted to heat the oil to the same temperature when the electric current was controlled with the pyrometer.

Based on the temperature of the oil in the popper, 8 levels of heat were used for the comparison of the 2 types of temperature controls. They were approximately 325°, 350°, 360°, 385°, 410°, 440°, 470° and 515° F. A blend of several popcorn hybrids to make up 10 samples of each size of sample was popped at each temperature. Two measures furnished with the popper; cup and half-cup, holding approximately 6-ounce and 3-ounce samples respectively, a 75 m.l. and 50 m.l. graduate were the 4 measures used for sample sizes.

A further test of temperature on popping volume was conducted using the pyrometric control over a range of temperatures from 340° to 440° F. using only the half-cup or 3-ounce measure. In all cases 10 samples of the hybrid Iopop 6 were popped for each treatment. Expansion is reported in units of the unpopped corn.

Recently the Popcorn Processors Association has adopted the practice of weighing the popping samples and measuring the popped sample in cubic inches per pound of raw corn. Normally a 150 g. sample is used as the popping charge. Accordingly, a further study was carried out using popping samples of 50-, 75-, 100- and 150-g. and reporting the expansion in cubic inches per pound. Five samples of a blend of popcorn hybrids for

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each of the 4 sample sizes were popped at 10° intervals over a range of 320° to 540° F.

Since previous experience had shown that the temperature of the raw corn had an effect on the popping expansion, all samples of corn were brought to room temperature before popping.

Coconut oil was used as seasoning with 25% as much oil by volume as raw corn used for each sample.

RESULTS AND DISCUSSION

Maximum and minimum temperatures indicated on the pyrometer of the O. V. T. when temperature was controlled with a thermostat and with a potentiating pyrometer when two sizes of samples were used are presented in Table 1. Temperature was adjusted so that oil in the popper was heated to the temperatures indicated in the second column of figures. Maximum temperatures are those indicated on the pyrometer when the current was cut out by the control and when the raw corn and seasoning were added to the popper. Minimum temperatures were the lowest indication of the pyrometer after the corn and seasoning had been added and the current was cut in by the control. Maximum temperatures generally were reached a few seconds after each sample had completed popping. The half-cup samples were not popped at the two highest temperatures because of burning and scorching at this level. There were some burned kernels at the highest level of heat with the cup samples. Use of the potentiating pyrometer to control popper temperature resulted in a slightly narrower range of temperature than when temperature was controlled by a thermostat.

Mean volume, standard deviation, and range in volumes of 4 sizes of popping samples popped at 8 temperature levels with the thermostatic and pyrometric heat controls are shown in Table 2. Direct comparisons are difficult to make since at any one temperature, the popper may have been slightly different for the two controls. Although the 2 controls were adjusted by heating oil in the popper bowl to the same temperature, the actual temperature for popping samples resulted in different maximum and minimum temperatures. Also, from previous experimental work, it was known that popping of a large or small size sample would have an effect on the expansion of a subsequent different size sample. Accordingly all samples of one size were popped at one time for each temperature level. Consequently, only the trend in means, ranges and standard devi-

TABLE 1

Maximum and minimum temperatures of popper when popping with thermostatic and pyrometric control adjusted to heat oil at seven temperatures and using two sizes of popping samples

Size of popping sample	Oil temp.	Popper temperature			
		Thermostat control		Pyrometric control	
		Min.	Max.	Min.	Max.
Half-cup	350°	295°	390°	310°	380°
Cup		255°	405°	275°	400°
Half-cup	360°	315°	410°	315°	400°
Cup		280°	425°	280°	415°
Half-cup	390°	345°	435°	345°	430°
Cup		295°	440°	295°	440°
Half-cup	410°	355°	440°	350°	435°
Cup		310°	455°	310°	445°
Half-cup	440°	350°	460°	350°	440°
Cup		315°	475°	320°	455°
Cup	470°	330°	570°	330°	480°
Cup	515°	370°	600°	350°	550°

TABLE 2

Mean, standard deviation and range of popping volume of four sizes of popping samples popped at different levels of temperature with two types of temperature controls adjusted to heat oil to each temperature level

Size of sample	Temperature of oil °F.	Mean volume		Standard deviation		Range in popping volume			
		Pyrometer	Thermostat	Pyrometer	Thermostat	Pyrometer		Thermostat	
						Low	High	Low	High
50 m.l.	325	30.1	28.5	.78	.96	29.3	31.5	23.9	31.5
75 m.l.		25.2	28.9	1.46	3.58	24.0	25.8	26.4	32.5
Half-cup		23.4	30.4	1.42	2.65	22.2	25.0	26.6	32.4
50 m.l.	350	30.1	29.3	.61	1.70	29.3	31.1	26.6	31.5
75 m.l.		29.2	27.4	.73	3.16	28.2	30.6	23.1	30.6
Half-cup		32.2	30.9	.93	.95	30.4	33.8	29.2	32.4
50 m.l.	360	29.4	26.6	.75	4.76	27.9	30.2	21.6	33.3
75 m.l.		29.2	27.5	.49	3.05	28.2	29.7	23.1	31.2
Half-cup		32.4	32.6	.49	.55	32.0	33.6	32.0	33.4
Cup		29.5	30.6	.79	.41	28.7	30.2	30.5	31.0
50 m.l.	390	25.6	24.3	1.99	6.15	23.9	28.8	18.1	32.9
75 m.l.		28.6	27.2	1.00	3.20	27.0	30.3	21.6	32.7
Half-cup		33.1	32.2	.33	.84	32.4	33.6	30.4	33.8
Cup		31.3	31.9	.25	.36	31.0	31.6	31.5	32.5
50 m.l.	410	20.2	19.7	1.41	3.17	18.5	22.5	15.8	26.1
75 m.l.		24.5	20.5	1.03	1.82	22.0	25.9	18.5	24.6
Half-cup		32.4	29.2	.55	.78	31.8	33.6	28.0	30.4
Cup		31.7	32.6	.56	.44	31.2	32.5	32.0	33.2
Half-cup	440	28.5	28.9	.83	1.06	27.8	30.2	26.8	30.2
Cup		32.7	32.5	.30	.64	32.2	32.9	31.9	33.4
Cup	470	32.9	33.1	.36	.32	32.4	33.2	32.7	33.5
Cup	515	34.0	33.7	.26	.26	33.6	34.2	33.4	34.0

ations may give worthwhile information. However, it may be noted that when the volumes were at the maximum, for the smaller size popping samples, the range and standard deviation generally were smaller when the heat was controlled with the pyrometer with little difference when the cup sample was used. This suggests that the more accurate temperature control as noted in Table 1 permits more accurate measurement of popping volume when small size samples are popped. At least, the size of the standard deviation and range for popping volumes of small size samples at a specific temperature was consistently smaller when using the pyrometric temperature control. In addition, the maximum volume for each sample size appeared to be obtained at different temperatures. With increasing size samples, higher temperatures were required for optimum volume.

Since there appeared to be a considerable effect of different temperatures on a given sample size, half-cup samples were popped over a range of 340° to 440° F. Mean volume of the half-cup samples and the range of volumes at each temperature are shown in Figure 1. Here again, the lowest error appears to

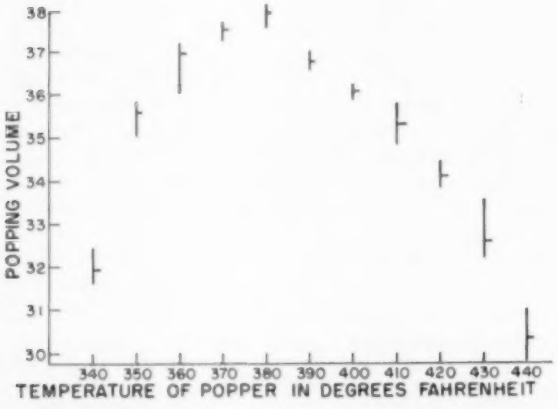

Figure 1. Range and mean of 10 half-cup samples popped at different temperatures.

occur when popping volume is near the maximum. Temperatures above or below this optimum temperature result in lowered popping volumes.

Since the Popcorn Processors Association has adopted the method of measuring popping expansion in cubic inches per pound while popping a 150 g. sample, further information was desired with this type of measurement using different size samples at varying temperature. The O. V. T. in use had been permanently converted to the potentiating pyrometric control described earlier.

Popping volumes for 50-, 75-, 100- and 150-g. samples over a range of 310° to 540° F. are shown in Figure 2. Because larger size samples would hardly pop at the lowest temperatures no data are shown. Since the small size samples scorched and burned at higher temperatures, they were not tested at these temperatures. Again, maximum volumes were reached

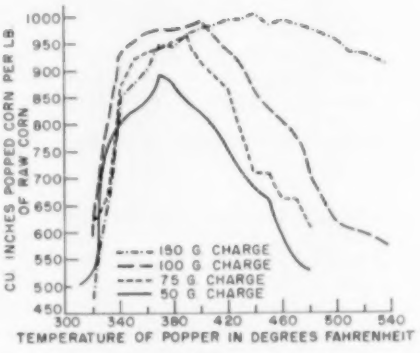

Figure 2. Effect of popper temperature on different size popping samples as measured by expansion of popped corn.

at successively higher temperatures as the size of the sample was increased. Also, as higher temperatures were used, the popping volume dropped most rapidly with successively smaller samples. However, in Table 2, the critical upper temperature was not reached with the cup sample. A cup sample weighs approximately 195 g., depending in part on moisture per cent and weight per bushel of the particular hybrid, and hence a drop in volume would not be expected except at a higher temperature than observed for the 150-g. sample size. Temperatures much below the optimum sharply reduced the volume of all size samples.

SUMMARY AND CONCLUSIONS

The proportioning pyrometer appeared to be more sensitive than the thermostat in controlling popper temperatures, especially when popping small samples. In addition there was less scorching of the corn at high temperatures when heat was controlled with the pyrometer.

The optimum temperature for maximum popping volume with the O. V. T. varies depending upon the size of popping sample. As the size of the sample was increased, higher temperatures were required.

Error of estimating popping volume was least when the optimum temperature was used.

Temperature of the popper was most critical in obtaining maximum volume with small size samples. Temperatures above or below the optimum resulted in rapidly decreasing popping volume.

Acknowledgment

Acknowledgment is gratefully made to Instrument Repair Service, Ames, Iowa for the use of a proportioning pyrometer and for assistance in mounting the pyrometric control on the O. V. T.

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Removal of Excessive Anthocyanin Pigment by Enzyme[a,b]

(Manuscript received May 11, 1958)

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Although most food technologists are concerned with the preservation of natural pigments in food products during processing and storage, there are some instances where the presence of natural pigment is excessive and partial removal is desirable or necessary. Concentrated products such as blackberry jams and jellies are too dark and unattractive. Yang *(7)* reported on the occurrence of excess anthocyanin pigment in blackberry wine. Pigment was found to precipitate during storage, leaving a dark purplish coating on the bottom or neck of the bottle. The phenomenon occurred either at the winery shortly after bottling, or on the retailer's shelf several months later. No apparent spoilage or undesirable change was noticed in the wine itself, but the appearance of the bottle rendered the wine unsalable. At that time it was found possible to hydrolyze the excess pigment and precipitate it by heating the wine to 180° F., and allowing it to stand for several days before bottling. Care must be exercised in this type of operation in order not to overheat the wine and impair its general quality. Enzyme removal of these pigments can provide greater control and more uniform results.

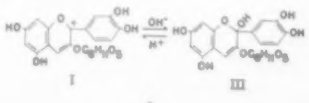
The decolorizing activities of certain fungal enzyme preparations on anthocyanin pigments have been reported by Huang *(2)*. In the experiments reported, it was found that the fungal enzymes (anthocyanases) were effective in decolorizing pigment extracts of strawberry, red and black raspberry, cranberry, blackberry, and grape. The degree of decolorization was found to vary from an 82% loss in absorbency for the blackberry pigment to a 22% loss in absorbency for the black raspberry pigment after 19 hours of reaction time.

The work reported by Huang *(2)* suggests the possibility of using anthocyanases on other food products. Amerine and Joslyn *(1)* mention that it is sometimes necessary to use the free-run juice of red grape varieties for the production of white wine. The fruit must be picked early in the season so that the pigment will not color the juice. Careful handling is required, since fruit with broken skins will impart color to the juice. Anthocyanase enzymes might permit the destruction of any color extracted with the juice. This could permit the use of more varieties of red grapes and also extend the length of the season during which such grapes may be used. Another food product for which anthocyanase enzyme might prove useful is in grape juice manufacture where after-sedimentation of pigment is a problem *(5)*.

The kinetics and reaction of anthocyanase enzymes have been studied extensively by Huang *(2, 3, 4)*. It has been found that the reaction is kinetically of the first order. The overall reaction may be represented as

$$A \xrightarrow{k'} B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} C$$

where k', k_1, and k_2 are apparent first order rate constants. "A" is thought to represent an equilibrium mixture of the chrysanthemin cation I and the pseudobase carbinol III *(2, 6)*:



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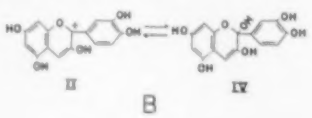
A

[a] Approved for publication by the Director of the Oregon Agricultural Experiment Station as Technical Paper No. 1130, Contribution of the Department of Food and Dairy Technology.

[b] Presented before the 18th Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 28, 1958.

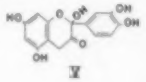
"B" is regarded as an equilibrium mixture of two corresponding cyanidin forms of I and III, and may be represented by II and IV:



II IV

B

"C" is a colorless product form of "B", i.e., from either II or IV or both:



V

C

In water solutions at pH 3.95, chrysanthemin exists as an equilibrium mixture of I and III *(2)*. Form I is responsible for the characteristic color of the solution. III is converted into I when the pH of the solution is lowered to less than 1. The presence of II is indicated by the residual color of enzyme treated solution, and IV is shown by the fact that a small increase in absorbeney is observed when the solution is acidified. The transformation of the colorless form "C" into II and IV is indicated by the slow intensification of color which follows.

The structure for "C" is believed to be represented by V because an open chain tautomer such as the chalcone derivative would be expected to exhibit a yellow color *(4)*.

EXPERIMENTAL

Blackberries of the Evergreen variety were used for experiments throughout this work. To study the relation between pigment removal and enzyme concentration, an aqueous solution containing 5% blackberry juice was used. A commercial preparation of the enzyme anthocyanase was employed in concentrations ranging from 0.02 to 0.20%. Blackberry solutions containing the enzyme were incubated at 80° F. Pigment removal was determined by measuring the optical density of the blackberry solutions at the wavelength of 510 mμ with a Model DU Beckman spectrophotometer. Measurements were made 8 hours after the addition of the enzyme and again after 24 hours.

To compare the general optical quality of the enzyme-treated blackberry juice with the untreated juice, absorption curves were obtained using the visible range of the spectrum from 400 to 650 mμ *(3)*. Five per cent aqueous solutions were used throughout.

The anthocyanase enzyme was then employed in the making of blackberry wine, jellies, and jams. Blackberry wine was made according to standard commercial procedures with 35% amelioration. The pH of the wine was 3.1, and the alcohol content 13% by volume. The enzyme was added at the beginning of the fermentation in concentrations ranging from 0.02 to 0.5%. The samples were stored in glass bottles at room temperature and visually examined periodically.

Blackberry jellies were prepared by first extracting the juice, then treating the juice with 0.1 to 0.5% of the enzyme. Treated and untreated juices were then filtered and made into jellies with pectin and sugar added according to standard jelly-making procedure, i.e., 221° F. and 65% soluble solids.

Blackberry jams were prepared by lightly crushing the berries, straining the juice, treating the juice with 0.1 to 0.5% enzyme, and filtering. The decolorized juice was then combined with the original berries and made into blackberry jams according to standard procedure.

Samples of blackberry jams and jellies were placed in glasses and were visually examined afterwards.

RESULTS

The relation between pigment removal and enzyme concentration is shown in Figure 1. The amount of pigment removed is in direct proportion to the concentration of the enzyme between 0 and 0.2%. It is also seen that virtually all the action of the enzyme took place within 8 hours at 80° F. No significant action was exerted by the enzyme after that time as shown by readings taken after 24 hours, although a small increase of enzyme activity was observed at higher concentrations.

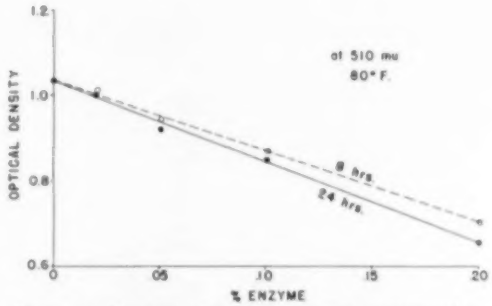


Figure 1. Pigment removal vs. enzyme concentration.

Figure 2 shows the general optical quality of the blackberry juice treated with 0.1 and 0.2% enzyme as compared to untreated juice. It is seen that the absorption curves of the enzyme-treated juice have the general optical quality of the untreated juice except that the peak at 510 mμ is proportionally lower with the increase of the enzyme concentration. Juice treated with 0.2% enzyme has a peak approximately twice lower than that treated with 0.1% enzyme. The otherwise identical shape of the curves denotes that the enzyme is very specific and that it acts only on the red and purple pigments to which the blue and green hues are complementary.

At the end of 2 months, untreated blackberry wine samples were observed to have formed a pigment deposit on the inside of the neck of the bottles. Samples treated with 0.1% enzyme or more deposited no

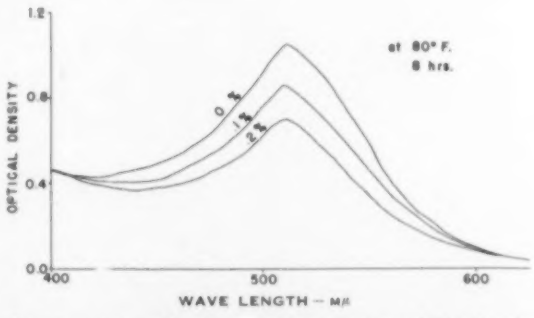


Figure 2. Absorption spectra of enzyme-treated blackberries.

Figure 3. Typical pigment deposits on wine bottles. Note heavy deposits on necks of two bottles at left.

pigment. Figure 3 shows the appearance of the bottles after the wine was emptied. The 2 bottles on the left were filled with untreated blackberry wine; the one on the right contained wine treated with 0.1% anthocyanase. Note the pigment deposit on the neck of the untreated bottles. They are typical examples of the problem experienced by the industry.

Blackberry jams and jellies treated with 0.1% of the enzyme in the manner described above produced brighter, redder, and more attractive products than the untreated jams and jellies. No large scale consumers' preference tests have been conducted, but a panel consisting of 10 housewives judged the appearance of the jams and jellies. Eight out of the 10 preferred the lighter enzyme-treated samples.

No flavor changes in the enzyme-treated samples were observed by the authors.

DISCUSSION

It is probably true that people who buy fresh blackberries expected the berries to look black rather than red, but the red and purple pigments, or anthocyanins, are naturally present in excess in blackberries, and could separate out in wine. Concentrated products such as jams and jellies become too dark to be attractive, and the excessive pigment in wine deposits a dark purplish coating on the inside wall of the glass containers.

Partial removal of the pigment by anthocyanase enzyme is probably the best solution. The enzyme is specific and acts only on the anthocyanin pigment. It works at room temperature, thus eliminating the danger of other changes at elevated temperatures.

The action of the enzyme is comparatively rapid. It completes its function overnight. This is fast enough for most practical purposes and imparts no danger of spoilage while waiting for the action to take place.

The method is applicable to other products, such as grape juice, in which pigment sedimentation is frequently associated. It is suitable for any food products that appear to be too dark due to the concentration of anthocyanin; partial pigment removal can improve and lighten their appearance.

SUMMARY

While most food technologists are concerned with the preservation of natural pigments in food products during processing, there are actually some instances where the presence of natural pigment is excessive and its partial destruction is in order.

A good example is in the case of blackberries where anthocyanin pigment is present in excess. The excessive natural pigment not only causes concentrated products, such as jams and jellies, to look unattractive, but also renders unsalable products in glass containers, such as wine. The excessive amount of pigment sticks to the inside wall of the wine bottle, and while the wine itself is in good condition, the customer shies away from the pigment-coated bottle.

Partial removal of the pigment is, therefore, desirable and even necessary. This is done in this experiment by the use of the fungal enzyme anthocyanase.

Blackberries treated with 0.1% of the enzyme produce brighter, redder, and more attractive jams and jellies. Blackberry wine so treated appears to be more stable with the absence of pigment deposit or precipitation during storage.

Acknowledgment

The authors wish to express their sincere appreciation to Rohm & Haas Co., Philadelphia, Pennsylvania, who generously supplied the anthocyanase enzyme used for this experiment.

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Industrial Syntheses of Carotenoids for Use As Food Colors[a]

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(Manuscript received May 11, 1958)

THE SYNTHESES of β-carotene, a yellow color in dairy products; lycopene, a red color in tomatoes and pink grapefruit; capsorubin, a red color in paprika; zeaxanthin, a yellow in yellow corn and poultry fat, as well as other carotenoids as naturally contained in our foods, may provide exceptional and very desirable colors for addition to processed foods. β-Carotene is now being produced in large commercial quantities by Hoffmann-La Roche *(6, 9)* chemical synthesis. Other carotenoids by synthesis are now in pilot production stage and may soon be ready for commercial application.

Historical developments in carotenoid chemistry are shown briefly, in chronological order, in Tables 1 and 2 *(8, 11)*. Karrer and Jucker's *(14)*, Goodwin's *(2)* and Hoffmann-La Roche *(6, 8, 9, 11)* publications are quite descriptive of carotenoid chemistry and the fundamental research involved. This paper, however, is necessarily limited to the synthetic carotenoids already in commercial application and to carotenoids which may reach this stage in the near future.

These fat-soluble carotenoid pigments that occur in many plants and also in marine and mammalian tissue impart color, which greatly influences consumer acceptance. Color additions are, in many cases, wanted to provide desirable appearance to certain foods which, because of inbreeding of certain characteristics and also growing conditions, are abnormally low in color.

Modern poultry management and high-caloric feeds, although yielding efficient meat and egg production, have lowered the color of egg yolks to the point of poor acceptance for use in colored cakes, noodles, salad dressings and desserts. Chicken fat high in color is preferred for processed chicken pies and chicken soups. Also, the fat of broiler chickens must have a certain degree of color to bring good market prices. These color requirements present the problem of carotenoid addition to modern poultry feeds which are, in many cases, deficient in these transferable pigments. Increasing the amounts of feed ingredients which have a high level of transferable pigment would, in most cases, not be practical in the high-energy feeds now used in modern poultry management.

The chemical production of carotenoids could provide natural pigments for coloring processed foods. β-Carotene is now available from both chemical and vegetable sources to standardize the color of margarine, shortening, cheese, bakery products and orange products. Large quantities of paprika are extracted mainly for red color, although the flavor of

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TABLE 1

Historical development—yellow carotenoids

	β-Carotene	Dihydro-β-Carotene	Xanthophyll	Zeaxanthin	Cryptoxanthin	Physalien	Bixin
1830	Wackenroder[1] 1831		Berzelius[1] 1837				Boussingault[1] 1825
1850							
1870				Thudichum[1] 1869			
1890							
1910	Willstätter[2] 1906	Wurst[1] 1918	Willstätter[2] 1907				Heiduschka[2] 1917 Kuhn[2] 1928–1931
1930	Karrer[3] 1929–1931	Karrer[3] 1931–1941	Karrer[3] 1930–1933	Karrer[3] 1929–1933	Yamamoto[1] 1932 Kuhn[3] 1933	Kuhn[1] 1929 Kuhn[3] 1929–1933	Weedon[4] 1951
1950	Karrer-Inhoffen[4] 1950 Isler et al.[5] 1953	Inhoffen[4] 1950		Isler et al.[4] 1955	Isler et al.[4] 1956	Isler et al.[4] 1955	

[1] First mention.
[2] Molecular formula.
[3] Constitution.
[4] Total synthesis.
[5] Commercial method.

TABLE 2
Historical development—red carotenoids

	Lycopene	Canthaxanthin	Astaxanthin	Capsorubin	Torularhodin	Capsanthin
1830						Branconnet[1] 1817
1850						
1870	Harsten[1] 1873		Pouchet[1] 1876			
1890						
1910	Willstätter[2] 1910					
1930	Karrer[3] 1929–1931		Kuhn et al.[4] 1933	Zechmeister et al.[4] 1934	Lederer[1] 1933	Zechmeister et al.[4] 1927
				Zechmeister et al.[2] 1935		Zechmeister et al.[3,*] 1927–1935
			Kuhn et al.[3] 1938	Zechmeister et al.[3,*] 1934–1935	Karrer et al.[4] 1943	Karrer et al.[3,*] 1927–1935
			Kuhn et al.[3] 1938		Karrer et al.[3,*] 1946	
1950	Karrer[5] 1950	Haxo[4] 1950				
	Isler et al.[6] 1956	Zechmeister et al.[5] 1956		Karrer et al.[3,*] 1956		
		Zechmeister et al.[5] 1956				

[1] First mention.
[2] Molecular formula.
[3] Constitution.
[4] Isolation.
[5] Total synthesis.
[6] Commercial method.
[*] Proposed structure.

the extract in many cases is objectionable. The red-colored carotenoids lycopene and canthaxanthin have been synthesized and may, in the future, be available for coloring foods. Synthetically produced carotenoids at levels used in food coloring are practically tasteless. Consequently, off flavors, as carried along in vegetable extractive pigments, are not a frequently occurring problem with the chemically produced carotenoids.

The Chemistry of the Synthesis of Carotenoids

The chemistry involved in the synthesis of β-carotene *(6, 8, 9, 11)*, lycopene *(7, 11)*, canthaxanthin *(11)* and other carotenoids is closely related to the Hoffmann-La Roche vitamin A synthesis *(5)* now employed by a number of chemical manufacturers. In this procedure, Figure 2, β-ionone is converted into C_{14} aldehyde, which, through additional steps, yields vitamin A. C_{14} Aldehyde of the vitamin A synthesis is transformed to C_{16} aldehyde and then to C_{19} aldehyde, two moles of which are condensed with acetylene dimagnesium bromide to yield, on further treatment, β-carotene.

Alpha and gamma carotene and also other asymmetrical compounds as occur with β-carotene in natural products do not accompany β-carotene *(7, 11)* in the Hoffmann-La Roche synthesis. The physical, chemical and biological properties of β-carotene by the Hoffmann-La Roche synthesis, Figure 1 *(8)*, are identical with β-carotene obtained from carrots and other vegetables.

The first Hoffmann-La Roche synthesis of vitamin A *(5, 11)* as shown in Figure 2 employs citral obtained from lemon grass oil as the starting material for β-ionone. Another Hoffmann-La Roche synthesis em-

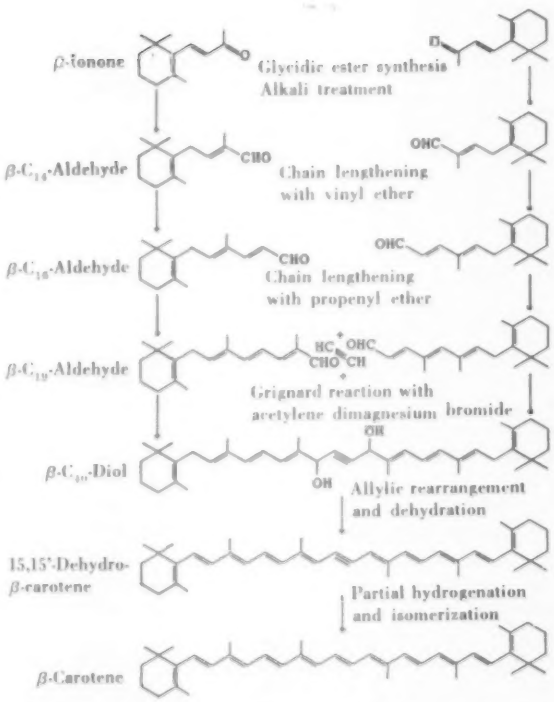


Figure 1. Industrial β-carotene manufacturing procedure.

ploys acetone for β-ionone synthesis *(15, 16)*, as shown in Figure 3.

Synthetic dehydrolinalool, an intermediate for a new synthesis of β-ionone, is converted through hydrogenation into linalool. Linalool, besides being an important perfumery aromatic, is the starting ma-

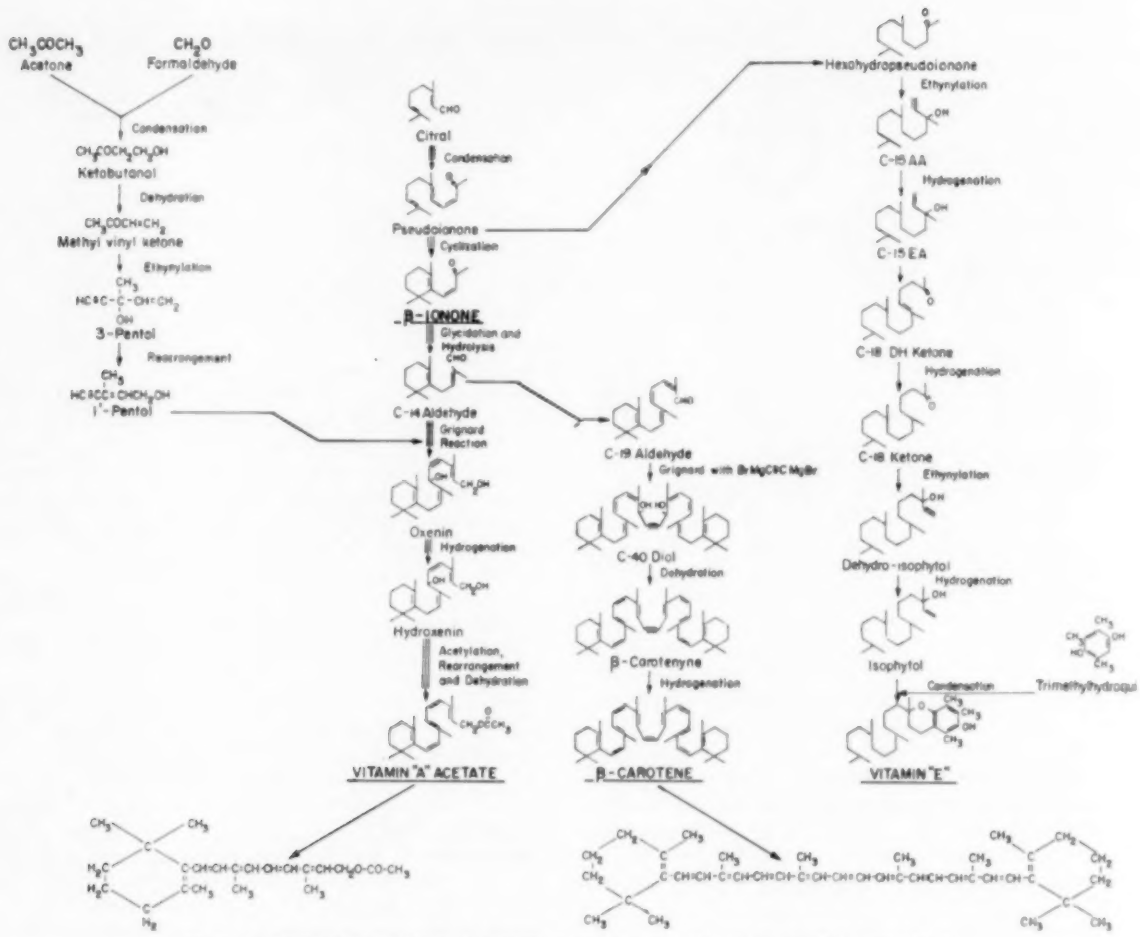


Figure 2. Synthesis of vitamin A acetate, β-carotene and vitamin E starting with citral.

terial for synthetic lycopene *(7, 11)*. The chemistry involved with the syntheses of the carotenoids also ties in closely with the perfumery aromatics, as shown in Figure 3. Economical production of vitamins A and E, as well as certain carotenoids and perfumery aromatics, are possible by this related chemistry.

Figure 4 shows the 5 steps involved in the synthesis of lycopene from linalool and crocetindialdehyde *(7)*. The final condensation yields lycopene which, after recrystallization melts at 173° C. Synthetic lycopene has been experimentally applied in coloring cheese and orange juice products.

Figure 5 shows the synthesis of zeaxanthin and physalien *(7, 11)* from acetoxy-iso-C_{19}-aldehyde following scheme $C_{19} + C_2 + C_{19}$. The Grignard reaction with acetylene dimagnesium bromide yields diacetoxy-iso-C_{40}-diol. Treatment of this product, first with hydrobromic acid and then with alkali, leads to 15,15′-dehydrozeaxanthin and is subsequently partially hydrogenated and isomerized into zeaxanthin. Physalien is obtained by esterification with palmitoyl chloride.

The condensation of acetoxy-β-C_{19}-aldehyde with β-C_{21}-acetylenic alcohol prepared from β-C_{19}-aldehyde leads to racemic cryptoxanthin, Figure 6 *(11, 12)*. It has the same melting point and absorption spectra as cryptoxanthin from natural sources.

Isozeaxanthin and canthaxanthin *(10, 11)* were synthesized from the dehydro-retro-C_{19}-aldehyde and acetylene. Treatment of dehydro-retro-C_{40}-diol with hydrogen bromide or phosphorus tribromide yields 4,4′-dibromo-15,15′-dehydro-β-carotene. Replacement of the bromine by hydroxyl followed by partial hydrogenation leads to isozeaxanthin which can then be oxidized to canthaxanthin, Figure 7.

Canthaxanthin, a very stable symmetric keto carotenoid, gives red solutions in fats and seems to have good possibilities as a food color, especially in combination with carotene for coloring of cheddar cheese and process cheese. The synthetic product is identical with a pigment of cantharellus cinnabarinus, an edible mushroom, and with a product of Petracek and Zechmeister *(18, 19)* obtained by the oxidation of β-carotene.

Figure 8 shows a simple and very efficient synthesis which provides various bixin esters easily accessible

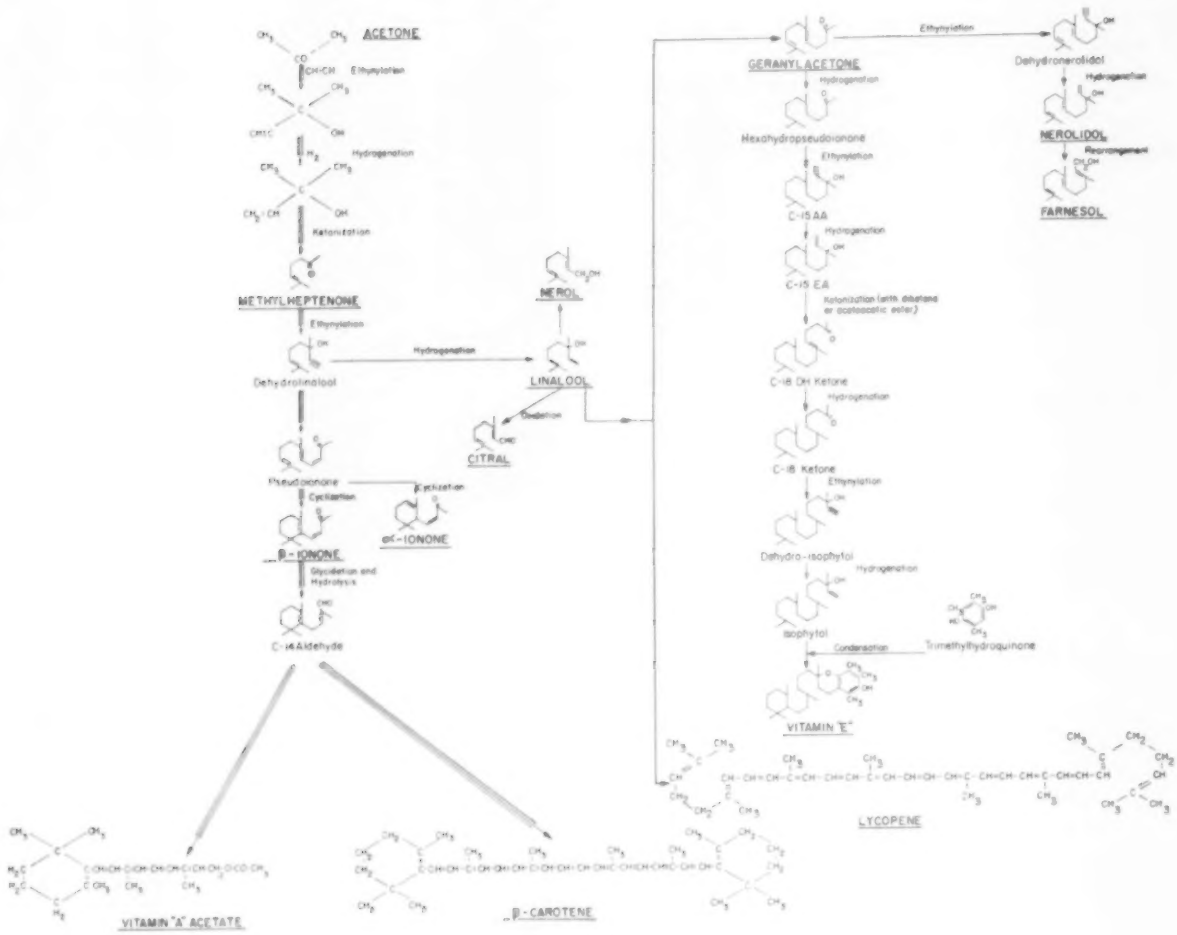


Figure 3. Synthesis of vitamin A acetate, β-carotene, lycopene, vitamin E and other compounds starting with acetone.

(11, 13). The transbixin synthesis thus follows the same lines as the lycopene procedure. Natural bixin, a cis-form, is lighter in color. Transbixin esters are less susceptible to pink or red color transformation than the cis forms *(14)*. The reddish color development is sometimes noted in cheddar cheese and process cheese. Color fading of the reddish cast may take place as sometimes noted in the mottled coloring of aged cheese.

Astaxanthin *(14)* and its keto and enol forms, astacene, which are red pigments of crustacea, are of interest because of their stability and possibilities for coloring foods and cosmetics. The potassium salt of astaxanthin is deep blue, which is readily susceptible to oxidation, forming a red color.

Capsorubin *(14)*, probably a symmetric hydroxyl carotenoid containing carbonyl groups, is one of the prominent red pigments of paprika, extensively used as coloring for salad oils and cheeses. Oleoresin of paprika, principally used for coloring, contains varying amounts of capsorubin, capsanthin, carotene, zeaxanthin, cryptoxanthin and perhaps other pigments. Growing locations, weather conditions, harvesting time and drying methods markedly affect the ratio of the different carotenoids and color concentrates prepared from vegetables. It is because of these difficult and almost uncontrollable factors that commercial production of synthetic carotenoids may help to eliminate some problems with food colors.

Crystalline carotenoids produced by chemical synthesis are of high purity and uniform color. The undesirable flavors sometimes associated with carotenoid extracts of vegetation are not a problem with the chemically produced carotenoids nor is color interference of certain analogs and isomers and other non-carotenoid pigments of plants. Controlled isomerization by chemical and physical methods can in some cases be applied to vary the color of carotenoids to meet certain requirements. The cis isomers are usually of less color intensity and of a lighter shade than the all-trans forms. Figure 9 shows the light absorption of β-carotene, 7,7′-dihydro-β-carotene and lycopene *(7, 8)*.

The infrared absorption curves of β-carotene and

lycopene, both synthetic and natural, are shown in Figures 10 and 11 *(7)*.

Applications

After synthetic manufacturing procedures reach commercial production, problems of application in food processing immediately arise. As an example, crystalline β-carotene has only limited solubility in fats. It is, therefore, micropulverized and suspended in edible fat *(1)* for application in margarine, colored shortening, cake mixes and other food products containing added fat. A gelled fat *(1)* suspension of β-carotene is practical for coloring butter during cold churning. Oil solutions are not of sufficient pigment concentration to be practical for many applications. Water-dispersible dry forms of β-carotene *(1)* and other carotenoids are especially suited for coloring orange drinks and canned fruit juices. The appearance of added carotenoids dispersed in the drink is like the natural carotenoid pigment suspended in orange and apricot beverages.

Methods of applying carotenoids as colorants have, in some cases, presented unusual stability problems. Lycopene as naturally present in tomatoes is light-stable under the conditions the fruit is handled but the pure crystalline form as such and in solutions and suspensions is very light-sensitive. Apparently the tomato contains a lycopene-stabilizing compound. Crystalline β-carotene decomposes slowly in the presence of oxygen but at moderate temperatures under inert gas it can be handled without appreciable decomposition. Under customary commercial handling, it is quite stable to oxidation when dissolved or dispersed in fat. Suspended in bottled fruit juices and beverages, its color stability exceeds that of the food dyes in the presence of reducing agents. Many

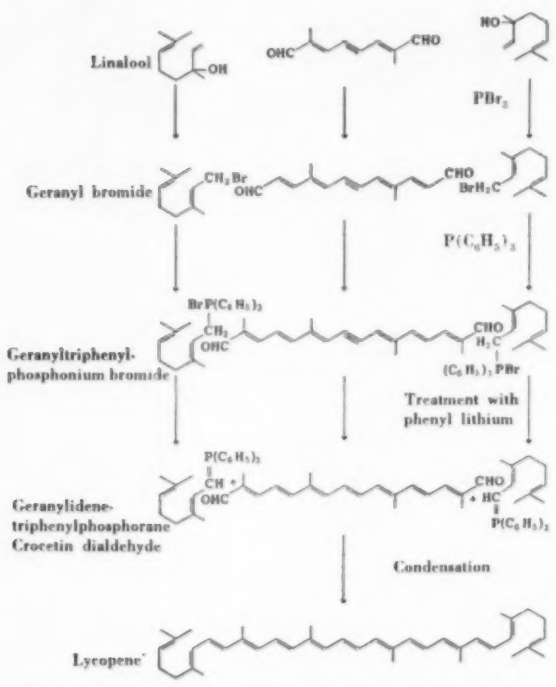


Figure 4. Lycopene from linalool and crocetindialdehyde.

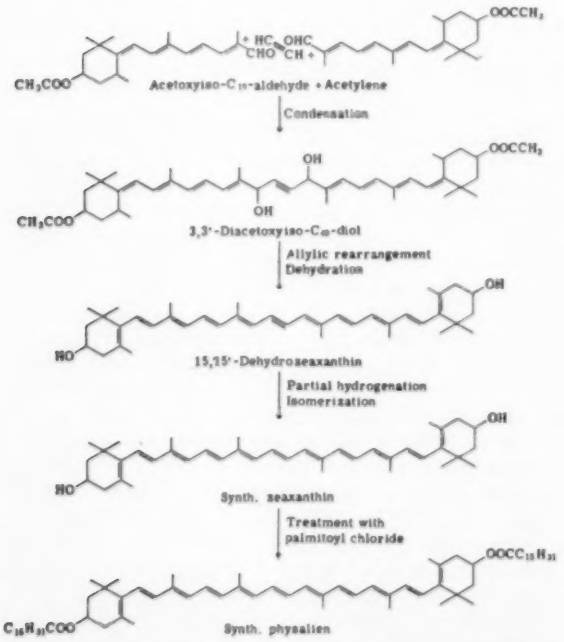


Figure 5. Zeaxanthin and physalien from acetoxy-iso-C_{10}-aldehyde.

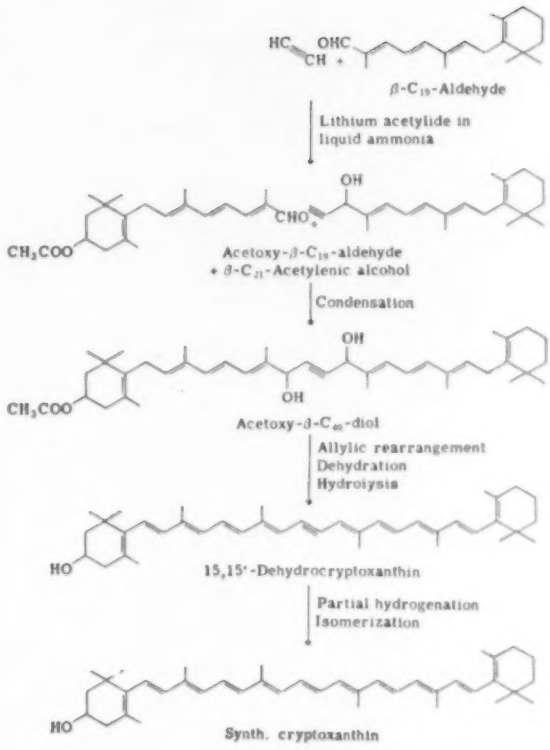
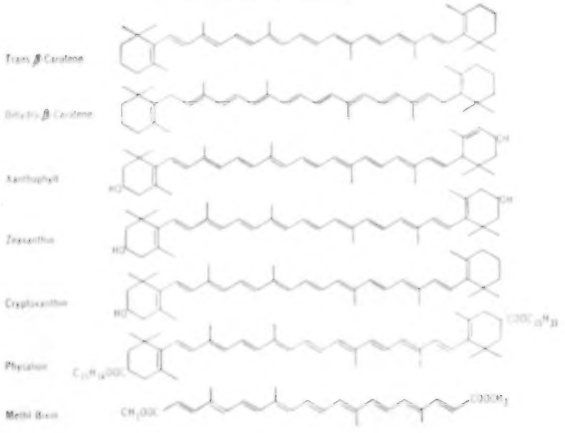


Figure 6. Cryptoxanthin from acetoxy-β-C_{10}-aldehyde and β-C_{10}-aldehyde.

Yellow Carotenoids



Carrots, chicken fat, eggs, oranges

Eggs, chicken fat, vegetables

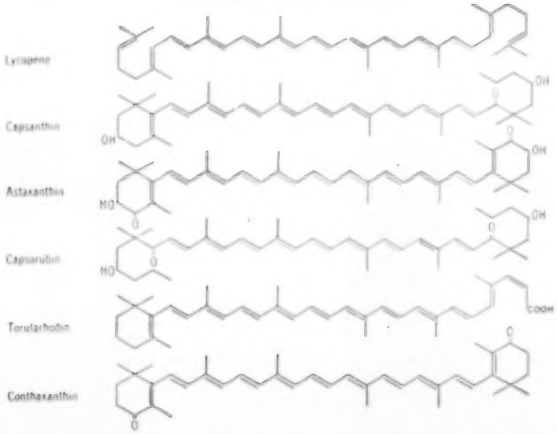
Eggs, yellow corn, liver

Eggs, yellow corn, oranges

Asparagus, berries

Berries (bixia orellena)

Red Carotenoids



Tomatoes, pink grapefruit, palm oil

Paprika

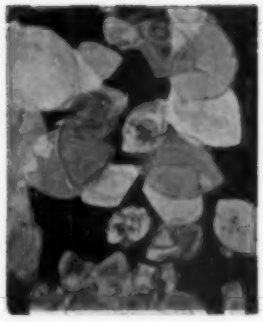
Lobsters, shrimp, salmon

Paprika

Torula yeasts

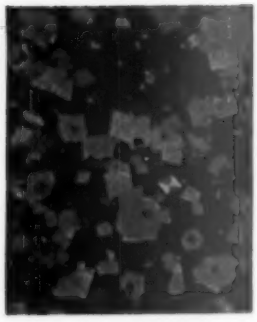
Mushrooms, tangerines (?)

Errata: "Physalion" should be Physalien. "$C_{15}H_{44}OOC$" should be $C_{15}H_{31}OOC$.
"Methl Bixin" should be Methyl Bixin
"Conthaxanthin" should be Canthaxanthin



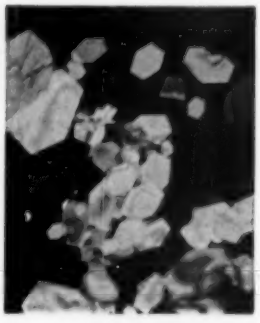
15, 15'-Dehydro-
β-carotene

15, 15'-cis-
β-carotene

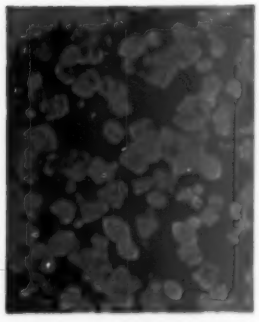


all-trans-
β-carotene

Canthaxanthin



7, 7'-Dihydro-
β-carotene

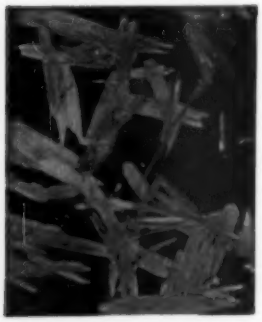


3, 4-3', 4'-Bisdehydro-
β-carotene

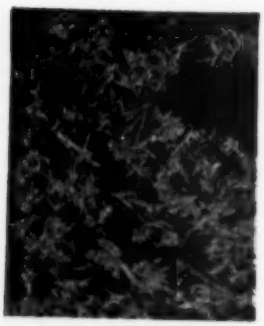
3, 4-Dehydro-
β-carotene

Dehydro-retro-carotene
(Isocarotene)

Lycopene



Zeaxanthin



Zeaxanthindiacetate

β-Apo-2
Carotenal

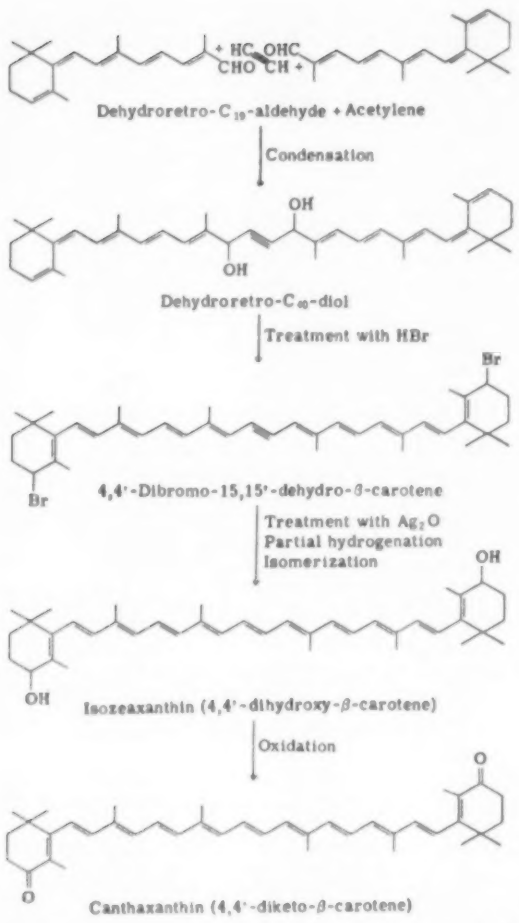


Figure 7. Isozeaxanthin and canthaxanthin from dehydroretro-C_{20}-aldehyde.

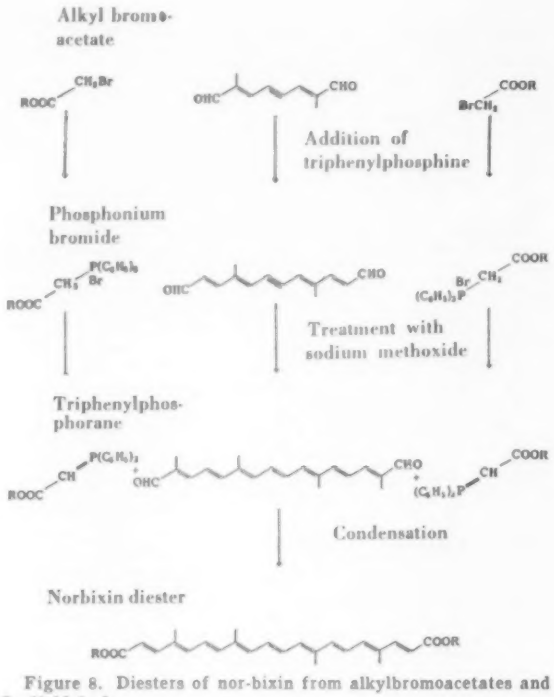


Figure 8. Diesters of nor-bixin from alkylbromoacetates and C_{20}-dialdehyde.

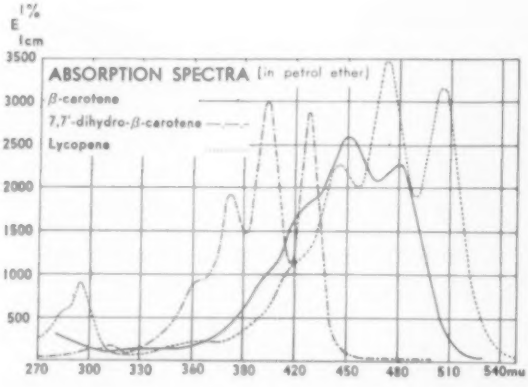


Figure 9. Light absorption of β-carotene, 7,7'-dihydro-β-carotene and lycopene.

of the food dyes are pro-oxidants, while the carotenoids have anti-oxidant properties that may have a bearing on flavor retention in canned fruit products.

The availability of pure carotenoids by chemical syntheses has provided material for controlled tolerance tests and also for clinical investigation of their physiological significance. β-Carotene, lycopene, 7,7'-dihydro-β-carotene and bixin show no health hazard in amounts many times the quantities which would be consumed in foods colored with these pigments. Blood plasma levels of β-carotene seem to be important in normal maintenance of the skin *(3)*. Utilization of β-carotene as vitamin A varies considerably with different animals.

Synthetic β-carotene is very satisfactory as the sole source of vitamin A. Dogs very efficiently convert β-carotene into vitamin A, resulting in high storage levels in the liver after massive doses. So far, hypervitaminosis has not been observed after large doses of β-carotene to rats, rabbits and dogs *(17)*. Chickens transfer very little β-carotene to body fat and egg yolk. On the other hand, carotenoid content of chicken fat and egg yolk color is markedly influenced by the cryptoxanthin, zeaxanthin, canthaxanthin and other hydroxy carotenoids in the feed. Also, feather color of birds is influenced by carotenoid intake. Yellow canaries and pink flamingos lose feather color when on a xanthophyll-free diet. Normal feather color returns when again adding zeaxanthin to canary feed and canthaxanthin to the flamingo's diet. Limited data already indicate a marked effect of β-carotene on skin pigmentation of people. These studies in animal and poultry nutrition and clinics present some very interesting speculations which require further investigation. Much importance is therefore attached to these recent developments and the research now in progress on carotenoids which are naturally present in our foods.

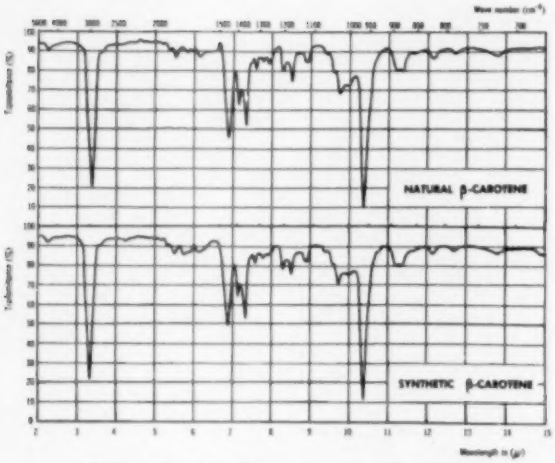


Figure 10. Absorption curves of β-carotene.

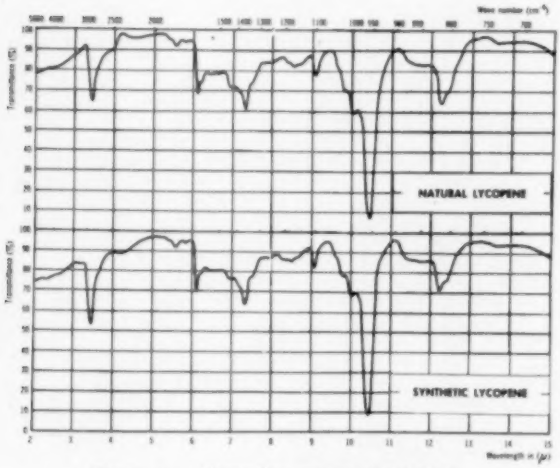


Figure 11. Absorption curves of lycopene.

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Coloring Fat-Base Foods with β-Carotene*

(Manuscript received May 31, 1958)

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THE AVAILABILITY of uniform quality crystalline trans β-carotene—as manufactured by the Roche chemical process in unlimited quantities—presents the food technologist with an acceptable yellow food color for fat-base food products. The aesthetic and psychological value of properly and attractively colored foods has long been accepted *(13, 18, 24)*. β-carotene is recognized as an internationally desirable food color, although the countries differ on labelling and legal details. Recently, WHO compiled the countries *(9)* where carotene is mentioned specifically on permitted food color lists, namely, Switzerland, Egypt, Spain, Portugal, New Zealand, Israel, Greece, Brazil, Austria, India, Sweden, and Norway. In the United States, Austria, Denmark, England, Finland, Germany, Sweden, The Netherlands, Norway, Switzerland, and Australia, carotene serves as a coloring and provitamin A for margarine.

Morton and Goodwin have recently reviewed carotenoid precursors and vitamin A chemistry and physiology *(31)*. Biological experiments have demonstrated full biological value for crystalline trans β-carotene as a provitamin A source *(27)*. Not only has the same biological activity been found for chemically produced β-carotene as for naturally produced β-carotene, but the chemical and physical properties have been demonstrated to be identical by German, Danish, Swedish, Swiss, and American research *(22, 23, 40)*. The characteristics of crystalline trans β-carotene as industrially produced are summarized in Table 1.

The limited solubility of crystalline carotene in oils has been one of the past principal deterrents to a wider application of this pigment in the food field. The purer the compound, the more limited the solubility. Crystalline trans β-carotene prepared by chemical synthesis possesses high purity as, when chromatographed on alumina or lime, one principal zone is obtained (Table 1). Solubility of crystalline β-carotene in organic solvents and vegetable oil was observed by Milhailovnina and Savinov *(29)*. Solution velocity was reported to be very slow and a tendency to form supersaturated solutions was noted. Variation of β-carotene solubility in edible vegetable oils is little affected by the composition of the oil *(30)*. The range of solubility of crystalline β-carotene in several solvents is presented in Table 1. Solubility was determined by agitating an excess of the carotenoid with the selected solvent at 24° C. for several days to establish equilibrium between liquid and solid phases. Fortunately, the low solubility phenomenon is not operative at the levels at which β-carotene is commercially added to foods.

* Presented at the 18th Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

TABLE 1

Characteristics of crystalline trans β-carotene, $C_{40}H_{56}$*

Appearance	Violet-red platelet crystals, free flowing. Stable only under inert gas or under vacuum.
Odor	Faintly aromatic, typical.

Ultraviolet spectrum (cyclohexane)

Wavelength, mμ	$E^{1\%}_{1\,cm.}$
340	150
454–455 max	2450
469–471 min	1970
482–484 max	2150

Chromatography, Al_2O_3 or $Ca(OH)_2$
On alumina or lime column yields single zone.
Biological activity
0.6 micrograms ≙ 1 U.S.P.U. or 1 I. U. of vitamin A

Solubility 24° C. (75° F.)	% by weight
Vegetable oils	0.05*–0.10
Orange oil, cold pressed	0.5–1.0
Ethanol	trace
Propylene glycol	insoluble
Glycerol	insoluble
Water	insoluble
Chloroform	3.0–5.0

* As industrially produced by the Roche chemical process.
* Equivalent to 375,000 U.S.P.U. of vitamin A activity per pound or 825,000 U.S.P.U. of vitamin A activity per kilogram.

MARKET FORMS

Solubility difficulties encountered in preparing market forms have been solved by the development and manufacture of special carotene products. Two approaches were used to overcome the solubility disadvantage of trans β-carotene, namely, (a) reduction in the crystal size and, (b) use of heat to prepare saturated oil solutions. Reduction in crystal size hastens the rate of solution and this principle easily adapts itself to the manufacture of marketable forms of β-carotene as described in Table 2. Those carotene preparations where the heating principle is used are described in another paper *(5)*. Hartmann and Barnett *(20)* were the first to reduce the size of crystalline β-carotene in the preparation of a useful carotene oil paste composition for food application use. Reduction in crystal size alone is not enough, however. A dry milling operation reduces crystal size but dry micropulverized crystalline trans β-carotene requires an inert gas atmosphere, or else it is subject to progressive oxidative destruction *(15)*.

The vegetable oil or hydrogenated fat of suspensions of micropulverized β-carotene provides a barrier to oxygen and air, and retards oxidation. The physical form of the vegetable oil carrier is also of practical concern. If a liquid vegetable oil carrier is used to prepare the β-Carotene Suspension, the resulting product has the physical advantage of pourability, but such suspensions, upon standing for prolonged periods (weeks), tend to show some settling of the suspended crystals, and hence bulk containers of these

TABLE 2

Special β-carotene application forms for fat-base foods

Form	Description	Uses
Micropulverized Powder	Orange-red crystalline trans β-carotene *powder*, 1 to 10 microns in size. Non-free flowing. Requires special milling operation for production. Inert gas packing and preferably cool storage required to maintain potency.	Like the crystalline β-carotene (Table 1). This form must be regarded as a research or special use product, a potential form for special processing needs.
β Carotene Liquid Suspension	Terra-cotta red liquid suspension of 30% micropulverized trans β-carotene in vegetable oil (equivalent to 500,000 U.S.P.U. vitamin A activity per gram). The product will pour at 70–90° F. At 40–50° F. it is a semisolid product. In *liquid* form, carotene crystals tend to settle out very slowly, and hence should be mixed or stirred before use.	For coloring margarine, shortening, lard, vegetable oil, process cheese, dried egg yolk, winter butter manufactured by the continuous process, etc.
β-Carotene Vitamin A Blend	Orange-red micropulverized trans β-Carotene Suspension in vegetable oil containing dissolved vitamin A acetate or palmitate. Carotene concentration 1% to 10%. Not physically stable, suspended carotene crystals settle out relatively quickly. Product recommended to be *packaged in custom batch-size units only*.	For simultaneous coloring and vitamin A fortification of margarine, mellorine, etc.
β-Carotene Semisolid Suspension	Terra-cotta red semisolid suspension of 24% micropulverized trans β-carotene in hydrogenated vegetable oil (equivalent to 400,000 U.S.P.U. vitamin A activity per gram). The product is semisolid to 90° F. At 100° F. and above, the product becomes liquid and may be poured. In *semisolid* form, the carotene crystals remain uniformly suspended.	For coloring margarine, shortening, lard, vegetable oil, process cheese, dried egg yolk, winter butter manufactured by the continuous process, etc.
β-Carotene Gel	Terra-cotta red gelled vegetable oil suspension containing 1% to 10% micropulverized trans β-carotene. When stirred or agitated, the gel structure is broken and the product readily pours. Physically stabilized in *gel* form, the carotene crystals do not settle readily.	For coloring winter butter manufactured by the batch process, home coloring of margarine, etc.
β-Carotene Standard Solution	Amber-orange *true solution* of β-carotene, 0.05%, in ethyl laurate. Physically and chemically stable in closed amber bottles under refrigeration (45–50° F.) for 6-month period.	*For analytical purposes only*. Available as a laboratory standard solution.

* A number of different market forms have been prepared, such as a cetyl alcohol composition of 15% soluble carotene, gelatin composition of 10% micronized carotene, etc., of only research or specialized application use.

suspensions should be stirred or agitated to insure homogeneity if the contents are used over intervals of time widely spread apart. By preparing this type of suspension at a high level of crystal content, namely, 30% β-carotene, the settling tendency is minimized.

Where preparations of combined β-carotene and vitamin A for the simultaneous coloring and fortification of margarine are required in an easily pourable composition, more dilute suspensions of micropulverized β-carotene in a soluiton of vitamin A in vegetable oil are employed. To insure homogeneity, these are packaged in custom batch-size, sealed containers directly after manufacturing. Settling out of the β-carotene in the sealed container is of no concern, since, in the use of the product, the can is flushed out with hot oil and the entire contents are used.

Where it is desirable to have the assurance of a physically stabilized product, micropulverized β-carotene, 24%, in a hydrogenated vegetable oil is recommended, since the semisolid character of the base holds back crystal settling. This form of product, at room temperature, 70–80° F., can be readily scooped out of a bulk container and weighed, or if heated to 100° F. or above, it becomes pourable. Another form of β-carotene has been developed *(2)*, described as β-Carotene Gel, in which micropulverized β-carotene is suspended at elevated temperatures in an edible vegetable oil composition containing an edible saturated fatty acid. When the carotene fatty acid vegetable oil mixture cools, a semisolid gel forms, which is retained at room temperature until the composition is stirred before use to become a pourable liquid. While this form of β-carotene enjoys unique characteristics for general usage, it is particularly useful in the coloring of butter churned by the batch process.

Although it is possible to prepare and market true solutions of β-carotene for food coloring applications, the low carotene content and the corresponding high oil content make them economically unattractive to the food industry. Where β-carotene is added to a food product, for example, egg yolk or butter, by one of the food application forms described in Table 2, it becomes desirable to know the initial natural carotenoid content of the food product. When this natural color is estimated in terms of β-carotene content, the technologist has desired as a laboratory standard, a true solution of β-carotene to expedite these determinations; hence, a solution of β-carotene in ethyl laurate as described in Table 2 is offered for analytical purposes only, not to be used for food coloring purposes.

STABILITY

Since the market forms for fat-base foods usually consist of micropulverized β-carotene suspended in a vegetable oil composition base, and are packaged and marketed in sealed containers, stability after manufacture has not been a problem, as indicated by the data in Table 3. The vegetable oil composition acts as an oxygen barrier, and if the headspace of the container is replaced by inert gas, CO_2 or N_2, stability is

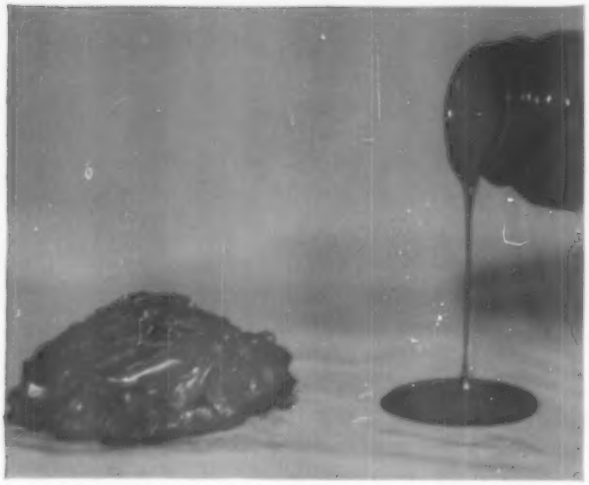

Figure 1. Physical Form of β-Carotene Suspension at Room Temperature (75°F). Left: 24% β-carotene semisolid suspension. Micropulverized trans-β-carotene in hydrogenated vegetable oil. Right: 30% β-carotene liquid suspension. Micropulverized trans-β-carotene in vegetable oil.

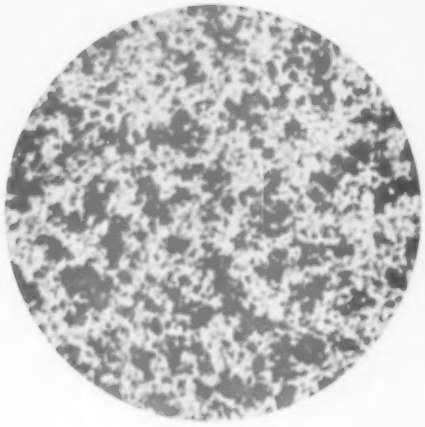

Figure 2. β-Carotene Suspension. High magnification showing uniform micropulverized β-carotene crystals throughout the suspension.

Figure 3. Fresh Egg Yolk Illustrating Natural Variation of Egg Yolk Color. Right: Light egg yolk color comparable to NEPA color scale No. 2. Left: Dark egg yolk color, NEPA No. 5.

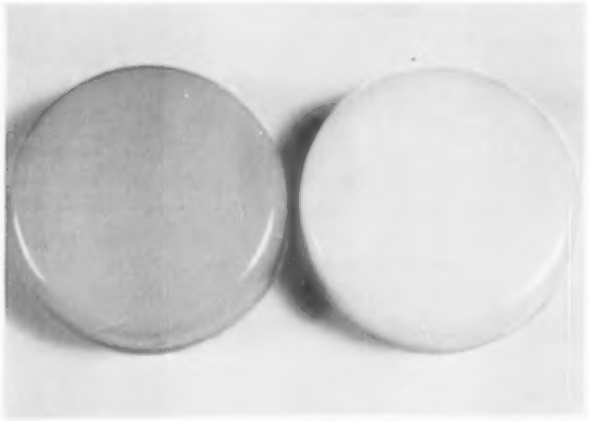

Figure 4. Frozen Egg Yolk in Glass Container. Right: Light egg yolk, NEPA No. 2, without β-carotene addition. Left: Same egg yolk with β-carotene addition prior to freezing to obtain color value comparable to NEPA No. 5.

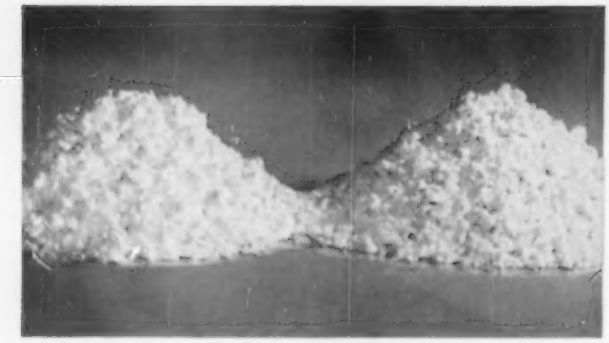

Figure 5. Spray Dried Egg Yolk. Left: Light egg yolk, NEPA No. 2 without β-carotene addition. Right: Same egg yolk with β-carotene addition prior to spray drying to obtain color value comparable to NEPA No. 5.

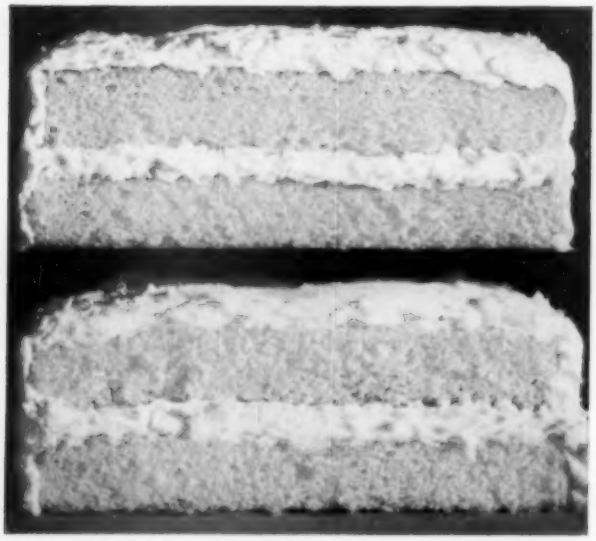

Figure 6. Layer Cake. Top: Prepared with β-carotene colored yolk, NEPA No. 5. Bottom: Prepared with light egg yolk, NEPA No. 2.

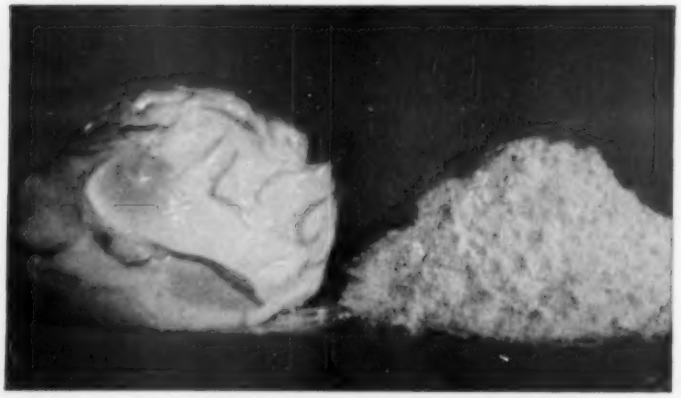

Figure 7. Fat and Powder Products Colored with β-Carotene. Left: Yellow shortening colored with β-carotene. Right: β-carotene colored flour suitable as carotene powder premix for coloring cereal and bakery products.

TABLE 3

Stability of market forms of β-carotene

Forms	Run	Potency	Container	Storage (% retention)		
				6 weeks		6 months 75° F.
				104° F.	113° F.	
		(% carotene)				
β Carotene Suspension	1	24.0	Sanitary metal can	.....	97	100
	2	24.0	Sanitary metal can	.....	92	100
	3	24.0	Aluminum tube	99	.....	100
	4	30.0	Sanitary metal can	98	.....	100
β Carotene Gel	1	1.0	Sanitary metal can	93	97	98
	2	3.5	Sanitary metal can	100	100	100
	3	3.5	Laminatedplastic pouch	100	100	97
	4	7.0	Laminatedplastic pouch	100	100	100
β Carotene Vitamin A Blend	1	1.4	Sanitary metal can	.....	100	100
	2	1.4	Sanitary metal can	.....	98	100
	3	1.6	Sanitary metal can	.....	100	.....
	4	3.7	Sanitary metal can	.....	100	.....

good. After months of storage in closed containers, the top surface of carotene preparations may show some color fading, due to slow oxidative changes by residual oxygen. The slight surface change, held to a minimum with inert gas packing and by an aluminum foil disc on the semisolid suspensions, do not result in a significant decrease in carotene potency or color value of the contents. All the micronized trans β-Carotene products—β-Carotene Suspension, β-Carotene Gel, β-Carotene Vitamin A Blend—may be safely held at storage conditions from refrigerator to room temperature (75° F.) for a 6-month-storage period. However, cool storage for these carotene concentrates is advised when possible. Prolonged storage at temperatures of 100° F. and above should be avoided. The effect of temperature on the physical nature of the market forms of β-carotene is described in Table 2. The difference in the physical form of the β-Carotene Liquid Suspension and the β-Carotene Semisolid Suspension is demonstrated in Figure 1. The appearance of the suspensions under high magnification is shown in the photomicrograph as Figure 2.

APPLICATION STUDIES

Laboratory and commercial trials were made with a variety of fat-base foods to determine the behavior of β-carotene in the colored food product and the adaptability of the market form of β-carotene to the food product. In many instances, a brief background of the utility of β-carotene in the respective food product is presented to better clarify the application study. The chemical determination of carotene in foods and other biological material has been recently reviewed by Booth *(4)*.

Butter. The natural color of butter varies with the season of the year and dairy feeding practices. Under typical winter conditions of feeding dairy cattle, if no artificial butter color is used, the butter will be almost white in midwinter, very yellow during the weeks of fresh, luxuriant pastures, and between these extremes, an intermediate color. Since this extreme change in color is decidedly objectionable to the consumer, the practice was started years ago, about 1886, in the United States, of using artificial color to make possible a nearly uniform shade of color throughout the year. Contrary to the usual American, Canadian, and European experience where winter butter is low in color and vitamin A value, the butter of New Zealand and Australia is the lowest in vitamin A and carotene during the summer season (February), even though the cattle are on good pastures; hence, a seasonal effect causing some decreased availability of carotene from the pasture is also believed operative *(26)* in addition to feeding practices *(14)*.

Not only does the natural color of butter vary over the year, but these changes are correlated with variable vitamin A value—8000 to 22,000 U.S.P. units per pound of butter. Part of this range of values is due to variation of true vitamin A in the product, but a very significant part is due to the variation in natural carotene content *(14, 26, 35, 41, 43)*.

Butter can be successfully colored with β-carotene both by the continuous and batch methods. Most of the butter in the world is still made by placing cold cream in wooden or metal churns of various capacities and churning it into butter. In this method of making butter, β-carotene can be added in the form of an oil solution; however, less oil is added if a concentrate of carotene, such as the β-Carotene Gel, is used. β-Carotene Gel can be added to the cream prior to churning or it may be added to the butter at the time the butter is salted. Richardson and Konar *(36)* have summarized the earlier history on carotene coloring trials with butter and observed that, when high quality carotene concentrates were used, no deleterious effects were observed, nutritive value was increased and coloring costs were not prohibitive.

Riel and Johns *(38)* report successful batch-type butter coloring trials with crystalline β-carotene manufactured by the Roche chemical process. Twelve churnings of butter were made using both First Grade and Second Grade cream, wherein β-carotene was added to cold, 32% fat cream (40° F.) in the churn previously pasteurized (170° F., 10 minutes). Prints of the salted (2%) butter, wrapped in parchment paper and boxed, were stored and observed for color, flavor and vitamin A potency, as summarized in Table 4. The authors conclude that butter colored with chemically produced β-carotene was acceptable in

TABLE 4

Flavor and color observations β-carotene colored butter (36) (12 churnings)

Storage	Color as β-carotene		Flavor[1]	Vitamin A[2]
	(γ/g. fat)	(mg./lb. butter)	(official grade)	(I.U./lb.)
Initial	10.6	3.85	36.5 (37.3)	12,700
2 Weeks, 50° F.	10.7	3.90	36.7 (30.7)	13,100
6 Months, −5° F.	11.2	4.07	32.5 (31.2)	13,500
6 Months, −5° plus 2 Weeks, 50° F.	10.7	3.90	23.8 (22.7)	12,800

[1] Figures in parentheses are for a non-carotene colored butter as a control.
[2] Includes vitamin A from carotene and true vitamin A.

color and flavor evaluation as well as by chemical evaluation, acid degree, peroxide and aldehyde values. Aust *(1)* also reports the favorable color and flavor findings for β-carotene colored butter in a study where the colored butter was examined by the Austrian Dairy Commission. Furthermore, the appearance of reddish and greenish tints usually associated with other types of butter colors were not observed in the β-carotene colored butter. Favorable German and Dutch butter trials with β-carotene are also described *(33, 40)*.

In the continuous butter manufacturing process *(42)*, after the cream is heated (120° F.) and separated as butter fat, carotene can be easily added in the form of β-Carotene Suspension, at which stage the micropulverized crystals of β-carotene quickly dissolve in the warm butter fat. Through cooperative studies between outside institutions and the Roche Applied Nutrition Laboratories, β-carotene colored butter samples were assayed to determine the uniformity of color and stability of the added β-carotene. Summarized data are recorded in Table 5.

The butter maker has always been interested in a quick, simple method for estimating the natural color of the fat in cream for calculating the amount of required color to add to each batch. Richardson and Konar *(36)* suggest a final butter color equivalent to 500 mg. of carotene per 100 pounds of fat (10 to 12 micrograms per gram of fat). Reinart and Brown *(34)* prefer that butter be colored to a total carotene concentration of 10 mcg. of carotene per gram of fat. Since currently there is a lack of uniform butter color standards as well as coloring methods, the use of β-carotene as the butter color and the adoption of solutions of β-carotene as butter standards would bring this standardization to the butter industry.

As emphasized by Riel *(37)*, using crystalline β-carotene as a coloring agent for winter butter adds approximately 4000 International Units of vitamin A activity per pound. This added β-carotene value would greatly assist in improving the vitamin A value of winter butter, establishing a minimum of about 12,000 to 13,000 U.S.P. units per pound throughout the year. These two advantages, therefore, namely, identity of β-carotene to the natural color already in butter, and the opportunity to restore the vitamin A value lost to winter butter due to seasonal effect or feeding practices, are the reasons why β-carotene is a preferred butter color. Cowgill *(7)* believes that a more uniform vitamin A butter is a worthy objective of the butter industry.

Margarine. Since margarine is a water-in-oil emulsion of partially hydrogenated vegetable oils and nonfat fluid milk, it, like butter as a table spread, requires a rich yellow color for ready acceptability. Coloring materials for margarine as used in the United States *(8)* as well as in other parts of the world *(6, 9, 37)*, are described in the literature. Espoy and Barnett *(10)* and Luckmann, Melnick and *Vahlteich (25)* present methods for the detection and determination of the coloring materials, carotene, annatto extract and FD&C colors, in margarine. The latter authors *(25)* in their analytical paper on the determination of vitamin A in margarine, point out that carotene, in addition to imparting a yellow color, acts as provitamin A. For this reason, credit must be given to this vitamin A contribution in the margarine analyses, while steps must be taken to prevent erroneously high vitamin A estimates being made in assaying margarine colored with other materials.

A recent treatise on technology of margarine manufacture by Crump *(8)* casts carotene as the ideal color for margarine as well as butter, and foretells the possibility that carotene may shortly replace all other coloring materials in margarine. Since β-carotene contributes vitamin A value, it is interesting to note

TABLE 5

β-carotene stability in colored butter

Type of churn	Form of carotene	Color appearance	Assay values after storage (milligrams of carotene per pound of butter)					
			Carotene added	Initial	2 mo. /40° F.	6 mo./40° F.	2 mo./ 40 + 75° F.[1]	2 mo./75° F.
Batch type New Jersey, January	β-Carotene Gel added to the cream (40° F.) before churning	Uniform	0	3.24	3.65	.....	3.54	3.60
			3	6.12	6.48	.....	6.48	6.48
Batch type Iowa, February	β-Carotene Gel added to the cream before churning	Uniform	1	3.24	3.30	.....	3.24	3.11
Batch type Pennsylvania, January +	β-Carotene Gel added to the cream before churning	Uniform	0	3.12	3.36 6.42	.....	3.36	3.30
			3	6.00		.....	6.30	6.42
Continuous type Canada, November	β-Carotene Suspension added to the warm butter fat	Uniform	1	3.60	.....	3.60	.....	.....

[1] Alternately subjected to 40° F. and 75° F. for 24- to 60-hour periods.

that, according to Harris *(19)*, the enrichment of margarine with vitamins A and D is at present mandatory in Denmark, United Kingdom, Italy, Norway, Sweden and India (Vanaspati). It is enriched on a voluntary basis in Australia, Austria, Belgium, Brazil, Canada, Germany, Finland, Greece Holland, Newfoundland, Portugal, Russia, South Africa, Switzerland, Turkey and the United States. In 1957, in the United States, about 50% of the margarine produced was colored with carotene, contributing one-third of the vitamin A value of the product.

Margarine, with added β-carotene, was prepared in commercial plants in batch-size units of 1800 to 3000 pounds. To the weighed amounts of warm margarine oil (110-130° F.), micropulverized β-carotene in the form of β-Carotene-Vitamin A Blend was added and thoroughly mixed until a clear, uniform solution was obtained prior to the emulsification step, after which the usual remaining production stages were followed. Samples of the 18 lots of margarine so prepared were subjected to initial vitamin A and carotene analyses as well as after storage of two and six months. Average data from these trials are shown in Figure 8. The stability results on β-carotene in margarine are in agreement with the excellent stability findings of Melnick, Luckmann and Vahlteich *(28)*, in which carotene of natural origin was added to margarine manufactured on a commercial scale and stored at 45° F. The stability data in Figure 8 are confirmed by the study of Geminder and MacDonough *(17)*, wherein vegetable oil suspensions of β-carotene were declared to have excellent stability and be readily adaptable for coloring margarine. In all the plant trial runs, no flavor defects were observed in the β-carotene colored margarine product. Coloring was uniform without mottling or speckling.

Schuchardt *(39)* describes successful margarine coloring trials with β-carotene in which the result was a pure yellow-orange color, without a greenish shade, which did not change during a 6 month storage period. Stability, taste and odor were not unfavorably influenced. While the data presented in Figure 8 are based on chemically determined values, an earlier report *(27)* shows excellent correlation of chemical

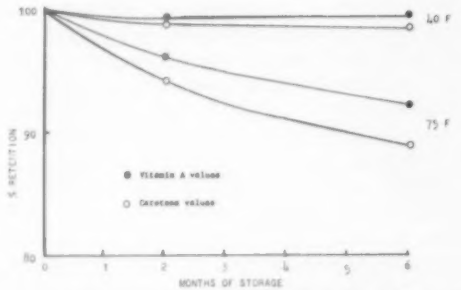

Figure 8. Stability of β-carotene and vitamin A in vitamin A fortified β-carotene colored margarine (18 commercial lots).

values with biological values as determined by the rat curative growth method on β-carotene colored margarine.

Shortenings. The desire of yellow color in hydrogenated vegetable oil, lard and liquid vegetable oils is another manifestation of one way whereby the homemaker may enhance the appearance of baked goods such as pie crust. Shortening seems to be an excellent vehicle for the addition of carotene to food products, both from the standpoint of color and color retention during baking.

After the shortening product has been clarified and deodorized, β-Carotene Suspension in the correct amount is added to the warm fat product (110–130° F.) with agitation, which is continued until complete solution is obtained. Subsequent treatment of the shortening, such as chilling, is accomplished in the usual manner. Data from some of the plant trial runs are presented in Table 6 which demonstrate the range of coloring added and also illustrate the stability of the added β-carotene under commercial packaging conditions.

Tests were run to obtain actual data on the behavior of carotene fortified shortening in cooking trials. For these tests, shortenings were fortified at three arbitrary levels, two of which are higher than current practice: shortening A, containing 4.2 mg. of β-carotene (7000 U.S.P.U. of vitamin A activity) per pound; shortening B, containing 9.0 mg. of β-carotene

TABLE 6

Color observation on β-carotene colored shortening and vegetable oil

Product	Form of carotene	Type of packaging	Appearance	Color as carotene (mg. of carotene per pound)		
				Initial	6 mo./40° F.	6 mo./75° F.
Hydrogenated vegetable oil	β-Carotene Suspension	1 lb. metal can	Evenly colored	3.80	3.72	3.72
Pure lard	β-Carotene Suspension	2 lb. carton	Evenly colored	3.24	3.36	3.24
Hydrogenated vegetable oil	β-Carotene Suspension	2 lb. metal can	Evenly colored	5.31	.....	.....
Hydrogenated vegetable oil	β-Carotene Suspension	1 lb. metal can	Evenly colored	5.04	.....	.....
				(mg. of carotene per pound)		
				Initial	3 mo./75° F.	6 mo./75° F.
Liquid vegetable oil	β-Carotene Suspension	Quart amber bottles air headspace	Evenly colored	3.66	3.42	3.12
Liquid vegetable oil	β-Carotene Suspension	Quart amber bottles nitrogen headspace	Evenly colored	3.60	3.54	.....
Liquid vegetable oil plus antioxidants	β-Carotene Suspension	Quart amber bottles air headspace	Evenly colored	3.54	3.54	3.54

(15,000 U.S.P.U. of vitamin A activity) per pound; shortening C, containing 12.0 mg. of β-carotene (20,000 U.S.P.U. of vitamin A activity) per pound; and the control, uncolored shortening. Three types of food products were prepared in the tests: cookies, pie crust and uncooked frosting. In planning these baking trials, attention was given to the ingredients containing natural carotene in an attempt to eliminate or standardize the natural carotene sources wherever possible. A control sample was prepared to determine the amounts present in the initial unbaked product. All baking trials were carried out in a home-style kitchen and baked in the oven of an electric home range in the Applied Nutrition Laboratory. Table 7 summarizes the baking trial data.

The three β-carotene additions resulted in evenly colored yellow shortenings of three definite shades. Baked food products containing these shortenings were evenly colored. Retention of carotene in the baked foods, varying from 75% to 95% of the added β-carotene, was found by analyses. The favorable carotene retention data reported here are comparable to vitamin A retention figures found in baking studies with vitamin A fortified margarine reported in an earlier study *(3)*. β-carotene colored shortening is illustrated in Figure 7.

Egg yolk products, frozen and dried. As a result of the confirmatory research by Ganguly, Mehl and Deuel *(16)*, β-carotene is now recognized as a minor coloring component of egg yolk, the major component being the hydroxy carotenoids typified by lutein, zeaxanthin, etc. Every country dweller obtaining fresh eggs from small poultry flocks knows that the yolk color will vary, the exact shade depending on the feeds consumed and other variables. Modern indoor management of large flocks and the extensive use of uniform commercial feeds has brought greater constancy of yolk color. This uniformity has been toward the light or yellow yolk desired by the fresh egg market and gradually decreasing the volume of dark or orange yolks required by food processors for the manufacture of properly colored noodle, mayonnaise and other products *(11)*. Light and dark egg yolks are illustrated as Figure 3. Dark egg yolk and yolk products used by the food industry are usually in the form of frozen egg yolk (plain, salted or sugared), frozen whole egg, frozen whole egg and yolk blends, dried egg yolk solids, dried whole egg solids and dried blends of yolk and whole egg. They are bought and sold on the basis of a color specification. The color of these yolk products has been expressed in terms of carotene by the Technical Committee of the National Egg Products Association as shown in Table 8.

Pohle and Mehlenbacher *(32)* have urged the adoption of carotene as a standard and proposed a method whereby an acetone extract of the yolk product could be measured in a colorimeter at 455 mμ and expressed in terms of carotene. Forsythe *(12)*, as the AOAC Associate Referee on egg color, favors crystalline β-carotene as an egg yolk standard.

Since β-carotene is already naturally present in egg yolk and since solutions of it are regarded as possess-

TABLE 8

Natural yolk color expressed as carotene units

NEPA yolk color	Color equivalents in terms of carotene
	(p.p.m. or γ/g.)
1 (very light yellow)	15
2	40
3	70
4	90
5	120
6 (orange)	150

TABLE 7

Stability of β-carotene in colored shortening in test kitchen trials

Food product	Color		Assay values (milligrams of carotene per pound)				
	Plate	Description	Natural carotene[2]	Added β-carotene	Unbaked	Baked[3]	Carotene retained[4]
							(%)
1. Vanilla Drop Cookies							
Control	Plate 9, 1-C	Creamy-white	0.25	0	0.29	0.33	....
Fortified-A	Plate 9, 2-E	Pale yellow-orange	0.25	0.94	1.29	1.23	95
Fortified-B	Plate 9, 2-F	Pale yellow-orange	0.25	1.96	2.49	2.36	95
Fortified-C	Plate 9, 4-G	Medium yellow-orange	0.20	2.90	.....	2.75	....
2. Pie Crust							
Control	.....	.....	0	0	0	.....	....
Fortified-A	.....	.....	0	1.32	1.37	1.21	88
Fortified-B	.....	.....	0	2.86	3.01	2.56	85
Fortified-C	.....	.....	0	3.89	3.57	3.09	87
3. Vanilla Cream Frosting							
Control	.....	White	0	0	0	.....	....
Fortified-B	Plate 9, 1-B	Creamy-white	0	0.73	0.87	.....	100[5]
Fortified-C	Plate 10, 2-B	Cream-yellow	0	0.98	0.93	.....	95

[1] Plate numbers and letters refer to color charts in Maerz, A, and Paul, M. Rhea. *Dictionary of Color*. New York: McGraw-Hill Book Co., Inc., 1st Edition (1930).

[2] Carotene content from ingredients.

[3] Corrected for moisture losses.

[4] Assayed as total β-carotene. Since trans β-carotene undergoes some isomerization to other stereoisomers when heated, actual vitamin A activity would have to be determined by biological assay if a specific nutritional claim is to be made.

ing color comparable to extracts of natural egg yolk, the approach of commercially adding β-carotene to weighed batches of yolk in the churning or mixing process prior to freezing or drying to produce the desired natural color grade has the advantage of flexibility, economy, absence of foreign coloring and nutritive improvement.

Various market forms of β-carotene have been added to frozen egg yolk products to provide additional color. The necessity of maintaining low temperatures (45–55° F.) in the yolk products during mixing and prior to freezing, makes complete solution of the β-Carotene Suspensions or Gel difficult. However, if β-Carotene Suspension or Gel is first uniformly dispersed in a portion of yolk at room temperature, this premix can be then immediately incorporated into the cold batch of yolk product. It is recommended that the mixed product be pasteurized by high capacity, multiple plate heat exchangers at approximately 140° F., followed by cooling, packaging and freezing. The pasteurization step insures complete solution of the added β-Carotene Suspension. Frozen egg yolk trials prepared as described above on a pilot-plant scale are summarized in Table 9.

When β-Carotene Suspension or Gel is added to mixed liquid egg yolk to be dried, the heat before and during the spray drying solubilizes the carotene and a uniformly colored product is obtained. Pilot-plant trials with spray-dried yolks containing added β-carotene are described in Table 9. These preliminary trials indicated that β-carotene losses were not great in either frozen egg yolk or dried egg yolk when β-carotene was added during processing as micropulverized carotene crystals (Suspension or Gel form). In another paper *(5)*, the excellent adaptation of a water-dispersible form of β-carotene for coloring egg yolk products is described. With this form, heat pasteurization of frozen egg yolk is not needed to dissolve the added β-carotene.

Frozen egg yolk (NEPA No. 2) increased in color as previously described with added β-Carotene Suspension, was thawed and incorporated in a baking trial of Vanilla Drop Cookies. The frozen β-carotene fortified egg yolk was used in the dough formula in place of regular egg yolk. Data were obtained showing excellent retention of carotene during baking, since 94% of the carotene assayed in the unbaked dough was recovered by assay of the baked cookies corrected for moisture losses.

Frozen as well as dried β-carotene fortified egg yolk was also used to prepare egg noodles, home style, from wheat flour, water, salt and salad oil. Using the frozen yolk product, a carotene recovery of 94% was obtained in the finished noodle product; while using the dried yolk product, a recovery of 96% was obtained. A third food product was prepared from β-carotene fortified frozen egg yolk, namely, homemade mayonnaise, from the ingredients—egg yolk, salad oil, white vinegar and salt. While the final product was not assayed, a uniformly colored creamy-yellow mayonnaise resulted.

Figure 4 illustrates the appearance of mixed liquid egg yolk, without β-carotene addition and with β-carotene addition. Furthermore, Figure 5 illustrates the appearance of these yolk products after spray drying. When yellow cakes were prepared from the two products, the improved color from the added β-carotene was apparent in the final cake as illustrated in Figure 6.

Process cheese. In the manufacture of cheese, the major portion of the fat of whole milk, from which it is prepared, is entrapped in the coagulated protein, and hence the variation in the fat-soluble component of cheese is a direct reflection of the variation in the butter fat of the original milk *(41)*. Realizing that milk and butter fat vary in natural carotene and vitaman A contents, Higuchi and Peterson *(21)* examined 383 samples of cheddar cheeses collected in Wisconsin between 1944 and 1945 with the findings summarized in Table 10.

The minimum values for carotene and vitamin A occurred in the March-April period when the cows had been off pasture for the longest time and spring pasturing had not been begun. While the authors found no relationship between cheese grade and vitamin A potency, they state that because of the im-

TABLE 9

β-carotene stability in egg yolk

Form of carotene	Frozen Egg Yolk		Assay values after storage (milligrams of carotene per 100 g.)		
	Container	Appearance	Initial	3 mo./−5° F.	15 mo./−5° F.
1. None (NEPA No. 2)	Polyethylene bag inside sanitary metal can	Uniform light yellow	3.6	3.3	4.0
2. β-Carotene Suspension,[1] Lot B23		Uniform orange	12.7	12.7	10.4
3. β-Carotene Suspension,[1, 2] Lot 909F		Uniform orange	13.5	13.5	11.3
	Dried Egg Yolk		(milligrams of carotene per 100 g.)		
			Initial	3 months' storage	
				45° F.	75° F.	86° F.	98° F.
4. None (NEPA No. 2)	Polyethylene bag in cardboard container	Uniform light yellow	6.2	4.8	4.3	4.5	4.8
5. β-Carotene Suspension,[1]		Uniform yellow-orange	23.4	22.6	20.4	21.4	21.7
6. β-Carotene Suspension,[1, 2]		Uniform yellow-orange	24.0	21.9	20.6	21.7	21.2

[1] β-carotene addition converts NEPA No. 2 yolk to NEPA No. 6.
[2] Laboratory preparation with especially small carotene crystals.

TABLE 10

Carotene content of cheddar cheese (21)

Period	No. samples	Carotene (γ/g.)	
		Range	Avg.
Jan.-Feb.	84	0.58–1.38	0.93
Mar.-April	96	0.40–1.33	0.78
May-June	75	0.75–4.45	2.34
July-Aug.	37	1.67–3.48	2.46
Sept.-Oct.	78	2.13–3.35	2.97
Nov.-Dec.	13	1.15–1.80	1.44

portance of vitamin A in nutrition, it would seem reasonable to include the vitamin A potency of the sample in establishing its grade.

With the development of special market forms of β-carotene, it is now technically possible to add β-carotene to primary cheese, such as cheddar *(5)*. It is also technically possible and feasible to color process cheese with β-carotene as described here. Added β-carotene gives cheese a rich yellow color between that of butter and egg yolk. Carotene is a permissible color in cheese, and since this addition would provide added vitamin A activity, the finished cheese could be so labeled.

Process, or processed, cheese was prepared by comminuting primary cheese and heating it in a jacketed kettle with added citrate and salt. β-Carotene Suspension or Gel is mixed into the hot melted cheese directly or can be first premixed with butter oil and/or melted cheese. The premix is then returned to the cheese kettle and mixing continues until the cheese proper is uniformly colored and heated to 160° F., after which time it is poured into boxes and packaged. Several lots of process cheese in small plant trial runs were colored with β-Carotene Suspension as described in Table 11. The carotene assay values for the β-carotene colored process cheese demonstrate fairly good carotene stability, although not as good as in the higher fat foods previously discussed.

These cheeses were sliced, packaged in paraffin coated film and exposed to incandescent and to fluorescent lights for 14 days in a standard refrigerated (40° F.) display cabinet. These samples could not be differentiated visually from similar samples stored in darkness, hence demonstrating good light stability.

Miscellaneous food products. Macaroni products from durum wheat possess a light yellow color contributed by the natural carotenoid content. However, when soft wheat, a low carotenoid wheat, is used, a correspondingly pale colored macaroni product results. Some countries, recognizing the naturalness of β-carotene, permit carotene coloring of semolina when durum wheat is in short supply. Several β-carotene market forms can be used. One method of providing a suitable coloring source for this industry is the preparation of a carotene colored flour or starch premix *(40)* as illustrated in Figure 7, which can be readily blended into the semolina. These carotene powder forms can also be used in the baking industry where acceptable food colorings are legally permitted. It can be used to color dry cake mix. Dry cake mix is discussed further in another report *(5)*.

TABLE 11

Behavior of added β-carotene to process cheese[1]

Form of β-carotene	Color appearance	Assay values (mg. of carotene per pound)		
		Carotene added	Initial	9 mo./40° F
Series 1				
1. None	Light cream	0	0.77	0.70
2. β-Carotene Suspension	Light yellow	6	5.40	4.50
3. β-Carotene Suspension	Golden yellow	12	14.2	10.60
Series 2				
4. None	Light cream	0	0.66	0.67
5. β-Carotene Suspension	Light yellow	6	6.1	5.5
6. β-Carotene Suspension	Golden yellow	12	15.3	10.9

[1] Packaged in paraffin coated film.

The golden brown color desired in the breading of food products, such as fish sticks, is produced by blending an oil dilution of β-carotene with the dry breading or by adding a water-dispersible form *(5)* to the batter prior to use. The color persists during the precooking, freezing, storage and subsequent reheating of the breaded product.

The color in French dressing is attributable in part to the condiments, paprika, vinegar, etc. Laboratory trials on the use of vegetable oil containing added β-carotene resulted in a light stable and natural appearing product.

Whipped cream and toppings, in which a creamy color is characteristic, were found to be stable vehicles for β-carotene. For a natural color, low levels are recommended in these products. Trials made with β-carotene colored shortening icings are recorded in Table 7.

Other products where β-carotene may find application are popcorn oil, cocktail tidbits, etc. As new uses are considered, preliminary laboratory trials should investigate the concentration of carotene and the market form best suited to the product. For carotene colored fat-base foods on which experience has been obtained, the following β-carotene additions are suggested as a guide: margarine, 3–4 mg.; shortening and lard, 4–6 mg.; butter, 0–3 mg.;; mixed liquid egg yolk (to be dried or frozen), 0–50 mg.; and topping, 0–1 mg. per pound.

SUMMARY

Several forms of micropulverized trans β-carotene, ranging in potency from 1–30%, have been described for the coloring of fat-base foods. The fine crystalline forms of these β-carotene formulations permit rapid solution of added carotene in the fat phase, at the desired carotene concentration for the specific food product, at a temperature of 100–130° F.

Method of preparation, physical properties and the stability characteristics of marketable forms of micropulverized β-carotene are described. Application studies with these forms of β-carotene are presented for the coloring of margarine, butter, shortening and lard, dried egg yolk and process cheese. Suggestions are given for coloring other fat-base foods, such as toppings, popcorn oil, salad oil and dressings, etc.

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Coloring Water-Base Foods with β-Carotene*

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β-CAROTENE, and other carotenoid pigments, are usually classed as natural fat-soluble pigments and their principle use in the food field has been in the coloring and enrichment of fat-base foods such as margarine, shortening, etc. *(3)*. Nature, however, has not confined carotene entirely to lipid systems but by means of protein complexes has enabled carotene to be dispersed in primarily aqueous systems. For example, Troitskii and Tarasova *(20)* have shown that carotene forms complexes with blood proteins which may contain as much as 21% β-carotene. The carotenoids in orange juice, tomato juice, carrot juice, etc. are most likely present in the form of complexes with proteins or lipoproteins. These examples, therefore, could be considered as illustrations of water-dispersible carotenoids in nature.

The principle method for introducing carotene into aqueous systems has been the formation of colloidal suspensions. This is usually accomplished by dissolving carotene in a water-miscible solvent and adding this solution to water followed by removal of the solvent. Several variations of this technique have been used *(13, 17)*. These methods produce an aqueous suspension of solid colloidal carotene which is not the same in color as an oil or solvent solution of carotene. An alternative method, therefore, is to emulsify oil solutions of carotene in water with the aid of empulsifying agents.

Although these methods can be used to produce a water dispersible form of β-carotene, in order to be economically feasible a commercial form must have a reasonable concentration of β-carotene in a convenient form which can be used in a small amount to produce a desired color effect in a finished food product. The normal limiting factor in the preparation of useful forms of β-carotene is the relatively low order of solubility in solvents and vegetable oils. For vegetable oils this is in the vicinity of 0.08%, and for organic solvents it reaches a maximum of about 4.0% in chloroform. Therefore the preparation of a colloidal form requires unduly large volumes of solvent for a practical process. Turning to the emulsion technique, it is found that the low levels of carotene in a vegetable oil saturated at room temperature limits the emulsion and the dry form prepared from the emulsion, to very low potency levels.

The problem of producing a dry form of β-carotene which was stable, water-dispersible and of a practical potency was solved by the discovery that a supersaturated solution of high concentration produced by dissolving β-carotene in hot vegetable oil would not crystallize from solution if it was rapidly emulsified before crystallization started. The resulting emulsion was then converted to dry beadlets, which retained the carotene in solution in the finely dispersed oil droplets for an indefinite period. Dispersion of the dry beadlet in an aqueous system did not effect the stability of the dissolved β-carotene in the fine oil droplets as regards crystallization.

This discovery opened up the way for the development of a stable dry beadlet form of β-carotene for use in coloring and fortifying water-base foods.

DRY β-CAROTENE BEADLET, WATER DISPERSIBLE

Preparation and physical properties *(2)*. This product is prepared according to the following procedure. A vegetable oil suspension of crystalline β-carotene stabilized by adding food approved antioxidants is heated to dissolve the β-carotene crystals. As soon as the carotene is completely dissolved, the hot solution is emulsified in a gellable colloid-plasticizer composition, such as a gelatin-sugar solution. The key to the successful preparation of this product is the complete emulsification of the hot β-carotene solution before crystallization of the carotene has started. Once the emulsification is complete, no further precautions are necessary and the emulsion is then sprayed and dried to a uniform dry beadlet product.

The carotene content of the beadlets can be varied to a certain extent, depending upon variables in the formula. A potency of 2.4% (approximately 40,000 I. U. vitamin A per gram) was chosen as the standard β-carotene content described as Dry β-carotene Beadlet Type 2.4-S, Water Dispersible.

The physical appearance of the dry β-carotene beadlets are shown in the photograph of Figure 1. They are spherical in shape with an orange-red color and a mesh size range of 30–80. The outer surface is irregular and this property aids in keeping the beadlets uniformly distributed in a dry mix. The beadlets are very hard and capable of withstanding high pressures. The appearance of the internal structure of the beadlet under high magnification is shown in the photomicrograph of Figure 2. The finely dispersed oil droplets containing the dissolved β-carotene can be seen throughout the interior. They disperse readily in water to give a cloudy yellow to orange solution resembling orange juice in appearance. Figures 5, 6 and 7 show the appearance of the water dispersion and demonstrate the rapid rate of dispersion of the β-carotene beadlet in water.

Method of assay. When β-carotene in any of its stereoisomeric forms is heated in solution to temperatures over 60° C., a rearrangement occurs so that the resulting solution contains an assortment of stereoisomeric forms consisting principally of all trans β-carotene, neo-β-carotene B and neo-β-carotene U with minor amounts of other isomers *(11)*. The actual proportion of stereoisomers present is dependent to a certain extent on the temperature, time of holding at temperature, etc., so that the equilibrium mixture can vary with treatment. This change also occurs very slowly at room temperature. These stereoisomers, however, are not unique to the laboratory but are found widely distributed in nature *(14)*. The carotenes of raw leafy vegetables averaged 76% trans β-carotene, 10% neo-β-carotene U and 10% neo-β-carotene B. Cooking of the vegetables increases the amount of the neo-forms. The β-carotene in fresh spinch, for example, is 78% in the trans form and after cooking this decreases to 58%, the balance of the β-carotene in each case being in the neo-forms. Alfalfa *(5)* and other feedstuffs also contain stereoisomeric forms of β-carotene.

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Since the absorption spectra of the cis forms of β-carotene differ somewhat from the all trans form, the colorimetric and spectrophotometric constants for the latter can not be used for stereoisomeric mixtures if true estimates of total β-carotene content are desired. Bickoff and co-workers *(4, 5, 6)* have extensively studied the problem of the assay of mixtures of stereoisomeric forms of β-carotene. These workers developed a method for the determination of the content of trans β-carotene, neo-β-carotene B and neo-β-carotene U in an isomeric mixture *(4)*. The principal method is based on the use of chromatography on a lime column using 1.5% p-methyl anisole in heptane as a developing solvent. By this method the three principal stereoisomers can be isolated and determined individually. An alternate method *(18)* involves the reading of solutions on a spectrophotometer at three different wavelengths and solving for the concentration of the three main stereoisomers by the use of appropriate equations.

A study of the stereoisomeric pattern prevailing in the dry β-carotene beadlets by means of lime chromatography revealed that the usual stereoisomeric distribution averaged 55% trans β-carotene, 35% neo-β-carotene B and 10% neo-β-carotene U. Lime chromatography, while undoubtedly the best primary method of analysis, is rather difficult to perform and is not too well adapted for routine assays, where only the total β-carotene content is desired. Consequently an easily performed assay for routine control purposes was needed.

Zechmeister and Tuzson *(21)* first produced stereoisomeric mixtures of carotenoids by the use of iodine catalysis. They observed that the addition of catalytic amounts of iodine to a solution of a carotenoid stereoisomer or mixture of stereoisomers resulted in a reproducible isomeric mixture of fairly constant spectrophotometric properties. The same stereoisomeric pattern develops regardless of the starting stereoisomer *(11)*. To determine the extinction values at the absorption maximum of the stereoisomeric equilibrium mixture a solution of all-trans carotenoid of known concentration is treated with iodine. With a knowledge of the extinction values thus obtained, an unknown stereoisomeric mixture can be treated with iodine, the extinction measured, and the total concentration calculated.

Based on these principles, the extinction of solutions of all-trans and 15, 15′ mono-cis-β-carotene of known concentrations in cyclohexane was determined after isomerization with iodine for three hours in the dark. An average $E^{1\%/1cm.}$ of 2230 at 452 mμ was found. By starting with two different stereoisomeric forms of β-carotene a double check was thus obtained on the extinction of the isomeric equilibrium mixture. The stereoisomeric β-carotene mixture extracted from dry β-carotene beadlets was treated with iodine under the same conditions but the change in extinction at 452 mμ was small enough to ignore for routine assay. Addition of iodine to the extent of 1 to 2% of the β-carotene followed by exposure to light is usually recommended for stereoisomerization of carotenoids *(11)*. It was found, however, that light caused some destruction of β-carotene, so that the use of higher iodine levels and allowing the solutions to stand in the dark was found preferable in this work.

The following assay method was therefore used for the routine assay of dry β-carotene beadlets.

1. Weigh out a 250 mg. sample.
2. Transfer sample to a 250 ml. amber or low-actinic separatory funnel containing 50 ml. of lukewarm distilled water and swirl to disperse beadlets in the water.
3. Add 50 ml. ethanol.
4. Extract solution 3 or 4 times with 50 ml. portions of Skellysolve B or petroleum ether (a few small scoops of NaCl or KCl added at this point will hasten separation of layers).
5. Combine extracts and make up to 250 ml. in an amber or low-actinic volumetric flask.
6. Dry solution with Mallinckrodt granular anhydrous sodium sulfate.
7. Pipette 5 ml. of the carotene solution into a 50 ml. amber or low-actinic volumetric flask, evaporate to dryness with a stream of nitrogen without heat and make up to volume immediately with cyclohexane.
8. Determine optical density (extinction) of solution *(7)* at the maximum, 450-452 mμ, in a Beckman spectrophotometer.

Calculations:

$$E^{1\%/1cm.} \text{ at } 452\ m\mu = \frac{E(452\ m\mu) \times V}{W \times 100}$$

E = measured extinction
W = weight of sample in grams
V = total volume containing W grams of sample

Calculate % Total β-Carotene

$$\%\ \text{total } \beta\text{-carotene} = \frac{E^{1\%/1cm.}\ (452\ m\mu)}{2230} \times 100$$

For use as a general method for the assay of stereoisomeric mixtures of β-carotene treat solution *(7)* with 2 ml. of a 2 mg. % solution of iodine in cyclohexane before making up to volume, allow to stand in the dark for three hours then read as in *(8)*. This will insure that the stereoisomers are at the correct equilibrium point.

VITAMIN A ACTIVITY

The vitamin A activity of trans β-carotene has been well established; one U.S.P. unit being equal to 0.6 micrograms of trans β-carotene or 1 gram of trans β-carotene is equivalent to 1,666,667 U.S.P. units of vitamin A. As is the case with vitamin A itself, however, the cis stereoisomers have varying vitamin A activity. Deuel, Johnston, Meserve, Polgar and Zechmeister *(12)* found the vitamin A activities of trans β-carotene, neo-β-carotene B and neo-β-carotene U to be in the ratio of 100 : 53 : 38, while Johnson and Baumann (16) reported the ratio to be 100 : 48 : 33. A good estimate for the relative activities of the β-carotene stereoisomers, therefore, would be 100 : 50 : 35 for the trans, neo B and neo U isomers, respectively. Using these values the vitamin A actvity of a stereoisomeric β-carotene mixture composed of 55% trans, 35% neo B and 10% neo U, for example, would theoretically have 76% of the activity of all trans β-carotene.

The vitamin A activity of the β-carotene in the dry β-carotene beadlet has been determined in our Nutrition Laboratories using the U.S.P. rat curative growth assay. This assay revealed that the β-carotene in the dry beadlets was practically equal in potency when compared to trans β-carotene in vegetable oil. On the basis of this assay the vitamin A activity of the 2.4% dry β-carotene beadlets is therefore considered equivalent to 40,000 U.S.P. units per gram.

It is entirely possible that the finely emulsified state of the droplets of the oil solution of β-carotene within the beadlet has resulted in an enhancement of the activity. Fraps *(11)* reported that, at low levels of feeding, the vitamin A value of the β-carotene stereoisomeric mixtures in various vegetables appeared on the average to be nearly equivalent to that of trans β-carotene in cottonseed oil when fed to rats. There are numerous reports in the literature indicating that utilization of carotene in the rat is dependent on the composition of the diet and the physical form of the carotene. Bio-assay studies on the vitamin A activity of dry β-carotene beadlets and other forms of β-carotene are continuing in our laboratories.

STABILITY STUDIES

It is well known that the carotenoids as a class are quite susceptible to destruction by exposure to air and light. Crystalline β-carotene must be stored under vacuum or inert gas to preserve it any length of time. Exclusion of oxygen is the most important factor because, in the absence of oxygen, light has much less destructive effect *(11)*. Use of antioxidants will prolong the life of carotene, but the exclusion of air has a more lasting preservative effect.

In the dry β-carotene beadlet, the carotene is well "sealed in" by the gelatin-sugar matrix so that the stability of the carotene in the beadlet is excellent. Stability tests on the dry β-carotene beadlets were run by storing in open containers for 10 days at 113° F. and 85% R.H., and for 6 weeks at 113° F. and 3, 6, and 12 months at room temperature in open and closed containers. Usual closures were used for the closed containers with no inert gas or vacuum protection.

The results of stability trials on several preparations of dry β-carotene beadlets are shown in Table 1.

TABLE 1

Stability of dry β-carotene beadlet, water dispersible

(Per cent retention of carotene)

Lab. No.	10 days 113° F. 85% R.H. Open beaker	6 weeks 113° F. Open beaker	6 months room temp., 75° F. Open beaker	12 months room temp., 75° F.	
				Open beaker	Closed vial
75–13	88	100	98	90	96
75–14	55	100	100	79	99
75–15A	75	100	100	90	93
75–16A	46	95	92	78	92
75–24B	50	100	87	82	100

It can be seen that the stability of the carotene is excellent so that packaging and storage offer no particular problems. While ordinary room humidity has little effect on the beadlets, the sugar-gelatin matrix of the beadlet will become tacky and tend to fuse at very high humidities. A combination of high humidity and elevated temperatures will result in carotene losses although preparations have been made which show quite good stability even under these rigorous conditions. (See preparation 75-13 in Table 1.)

APPLICATION STUDIES

Studies were made of a wide variety of foods to determine the adaptability of dry β-carotene beadlets for coloring purposes. The results of some of these studies are reported here.

Citrus beverages. The color of citrus fruit is due to carotenoids and a wide variety of these pigments have been found in the peel and juice *(7)*. Curl and Bailey have completed very extensive studies of the *(9)*. Some of the pigments which are present, such as the carotenes and cryptoxanthin, contribute vitamin A value as well as color. There is also a wide variation in the amounts of carotenoids found in citrus fruit, depending on the species, stage of maturity, region in which they are grown and seasonal variations *(7)*. Taylor and Witte *(19)* made an interesting study of the variations of the carotenoid content of oranges which involved determinations on 164 samples of fruit of various species, sampled at different seasons from both Florida and California. They found the following range of carotenoid content in milligrams per liter of juice: California Valencias, 0.65–2.74; California-Washington Navels, 0.32–2.97; Florida Valencias, 0.18–1.05; Florida pineapple oranges, 0.05–0.80; and Florida assorted oranges, 0.16–0.70. A comparison of the average values is shown in the graph of Figure 8. As an example of the variation that can be encountered in a given variety of orange from the same area, the graph of Figure 9 shows the carotenoid content of 14 samples of California Valencia oranges at various seasons of the year. The graph of Figure 10 shows the seasonal trend in carotenoid content for the California-Washington Navel oranges plotted by averaging the data of Taylor and Witte. Shown on the same graph are data obtained by our laboratories on samples of Florida frozen orange concentrate from different seasons of the year.

These data illustrate the difficulties which are encountered by the packer when attempting to produce a product of reasonably uniform color throughout the year. The utility of the dry β-carotene beadlet for coloring citrus beverages was demonstrated by forti-

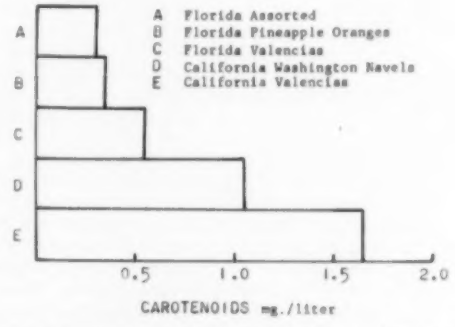


Figure 8. Average carotenoid content of juice from varieties of oranges.

(Data from Taylor and Witte [19])

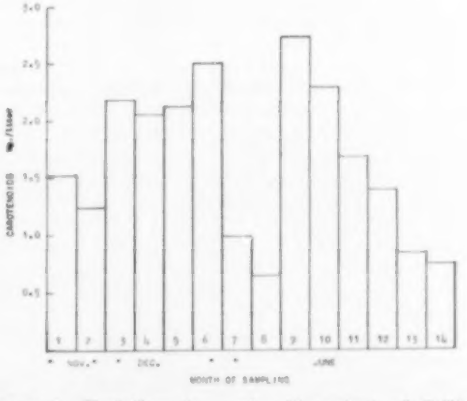


Figure 9. Variations in carotenoid content of California Valencia oranges.

(Data from Taylor and Witte [19])

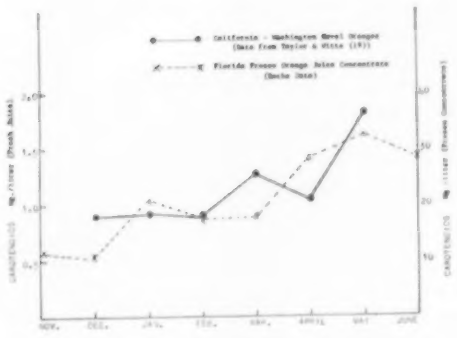


Figure 10. Seasonal variations in carotenoid content of oranges.

fying a heat-processed, canned beverage and a bottled carbonated beverage with β-carotene.

Canned citrus beverage was fortified with dry β-carotene beadlets and packed in standard enamel-lined cans and in plain tin cans. For each 50-gallon batch, 45 grams of 2.4% dry β-carotene beadlets were used. This is the equivalent of 0.67 mg. of carotene per 4 fl. oz. A standard closure was used in processing the drink. Sample cans of each batch were then subjected to stability studies. The results of the studies are shown in Table 2. The stability of the carotene was very good and a taste panel evaluation revealed no off-flavors contributed by the carotene. This level of carotene fortification contributes 1120 U.S.P. units of vitamin A per 4 fl. oz. of beverage as well as strengthening the natural orange color. The photograph of Figure 3 shows orange juice from three seasons of the year, which illustrates the color variation usually encountered. The early and midseason juice has been standardized to the color of the late season juice by the use of dry β-carotene beadlets.

A standard orange beverage syrup was prepared and 300 mg. of dry β-carotene beadlet and 100 mg. of ascorbic acid were added per 5.35 ounces of syrup. The pH of the syrup was adjusted to 3.2. To each bottle was added 5.35 ounces of syrup and the bottle filled to 29 ounces with carbonated water at 55 pounds per square inch to give 3.5 volume of CO_2. The final beverage had a claim content of 12,000 U.S.P. units of vitamin A and 87 mg. of ascorbic acid per 29 ounces. The bottled beverage was then placed on stability studies under various conditions. The results of the studies are shown in Table 3.

TABLE 2

Stability of β-carotene in canned citrus beverage

Sample	Storage period	Total carotenoids	
		(mg./4 fl. oz.)	(% retention)
Enamel lined cans	Initial	0.66	98
	2 mo./86° F.	0.66	98
	2 mo./98° F.	0.62	92
	6 mo./75° F.	0.60	89
Plain tin cans	Initial	0.65	96
	2 mo./86° F.	0.69	100
	2 mo./98° F.	0.69	94
	6 mo./75° F.	0.64	91
		0.61	

TABLE 3

β-Carotene and ascorbic acid stability in carbonated orange beverage

Storage condition	Carotene	Ascorbic acid
	(mg./29 oz)	(mg./29 oz)
Initial	7.62	....
1 month, direct sun	6.78	90
1 month, south window	7.18	90
1 month, 86° F.	7.68	93
1 month, 104° F.	7.50	87
2 months, direct sun	6.24	102
2 months, room temp., 75° F.	7.18	....
2 months, 86° F.	7.18	....

The stability of both the β-carotene and the ascorbic acid was excellent under adverse conditions. The photograph of Figure 4 shows the effect of sunlight on the stability of β-carotene in the presence of ascorbic acid. After 2 months' exposure, there was little change in color, while in contrast, the FD&C colors with ascorbic acid faded after two days of exposure.

The flavor of the beverage was also compared after three months' storage at room temperature with the flavor of a refrigerated sample. The flavor was judged to be unchanged.

Due to the fact that the oil phase in the dry β-carotene beadlets was not adjusted in specific gravity, there was some creaming or "ring" formation in the bottles on storage. Further work is underway to prevent this creaming or "ringing" phenomenon.

Primary cheese. Dry β-carotene beadlets (2.4%) were used successfully in coloring a primary cheddar cheese according to the following procedure using a level of 1 mg. of carotene per quart (2.15 lbs.) of milk. These trials were run in cooperation with a Canadian university. The dry β-carotene beadlet in the amount of 14.5 g. (348 mg. of carotene) was dispersed in 1 liter of water and added to a vat containing 750 lbs. of raw milk and 10.5 lbs. of starter.

The milk fat content was 3.6% and the starter acidity 0.75%. The milk was agitated until the acidity reached 0.18%. At first specks of color were noticed on the surface of the milk, but these dispersed after mixing. The rennet was then added and the milk allowed to set. The curd was then cut and the temperature increased to harden the curd and separate the whey. The color of the whey from the carotene colored cheese was exactly the same as a control batch without added carotene. The curd had a very good natural orange color very similar in color to that obtained with present cheese colors. The cheese was then salted, pressed and dried and then placed on storage studies which have not yet been completed.

Egg yolk products, frozen and dried. As part of a larger study of egg yolks colored with different market forms of β-carotene *(3)*, dried and frozen egg yolks were processed and colored with dry β-carotene beadlets. The stability of the β-carotene in the yolks and the use of the carotene-fortified yolks in the processing of some food products which normally contain egg yolk were studied.

The amount of β-carotene used was based on the amount required to raise the color of standard egg yolk natural color NEPA No. 2 to standard egg yolk color NEPA No. 6. One hundred and ten parts per

million of β-carotene were added to the yolks (125 g. of 1.2% dry carotene beadlet per 25 pounds of yolk). The beadlets were added to a small volume of lukewarm water and stirred or shaken. The resulting dispersion was added to the cold egg yolk in the mixing churn. The carotene-fortified egg yolk was then frozen or spray dried.

After processing the dried egg yolks were subdivided and placed in small polyethylene bags and refrigerated at 45° F. A stability study was set up to include data for the carotene stability in the dried yolks after storage periods of 45° F., 75° F., 86° F. and 98° F. (See Table 4). The contents of an open can of frozen yolks were subdivided and placed in amber glass bottles and small polyethylene bags and held at −5° F. to be assayed at appropriate intervals. (See Table 5).

From the tables it can be seen that dried yolks fortified with β-carotene are relatively stable at various storage temperatures up to three months and show less than 20% loss at various storage temperatures up to a year. Frozen yolks fortified with β-carotene are stable when stored up to three months and show approximately a 12% loss for over a year's storage.

The frozen egg yolks were used to prepare mayonnaise and found to give a uniform, rich, natural-appearing color. Both the frozen and dried yolks were also satisfactory in the preparation of noodles.

Eggnog. The color of an eggnog is primarily dependent on the color of the yolks of the eggs used. The use of β-carotene enables the standardization of the creamy appearance of eggnog regardless of the color of the egg yolks employed in its preparation.

Dry β-carotene beadlets were used to color commercial type eggnog. The following amounts of carotene —1.8, 2.4, 3.0 and 3.6 mg. (equivalent to 3000, 4000, 5000 and 6000 U.S.P. units of vitamin A) per quart— were added to a commercial type eggnog prepared according to the recommendations of Anderson and Jackson *(1)*. Various methods of adding the beadlets were tried but the fastest method was dispersion of the beadlets in 10 ml. of lukewarm water and adding along with the milk. An untreated control was prepared for comparison with the colored samples. Spices and flavorings were omitted and egg yolks very light in color were used.

The eggnog prepared at the 3.0 mg. (5000 U.S.P. units) per quart level and the untreated control sample were assayed after 4 days' refrigeration at 40° F. and found to contain 3.27 and 0.32 mg. of total carotenoids per quart, respectively. The colored eggnogs and the untreated control sample were examined visually. The untreated control sample appeared to be chalk white in color. The 1.8 mg. sample showed a very slight creamy hue and the 2.4 mg. level was slightly more creamy in appearance. The 3.0 and 3.6 mg. samples, however, were a rich creamy color with no distinguishable differences in intensity. The addition of carotene to eggnogs prepared from egg yolks low in color, therefore, produces a creamy natural and appealing hue.

Ice cream. As a dairy product ice cream is important in the human diet *(15)* and as a dairy product containing appreciable butter fat, it is the carotene and vitamin A content that would be expected to vary, although no detailed study has been published on this point. Dahlberg and Loosli *(10)* acknowledge vitamin A variation and on the basis of data collected on ice cream made from June-July cream, give an average value of 548 U.S.P. units of vitamin A per 100 grams for ice cream. Mellorine, a frozen vegetable fat dessert, like dessert, like ice cream, can be colored with carotene to provide both coloring and vitamin A value.

Vanilla ice cream was fortified with β-carotene to produce a French vanilla type ice cream. Dry β-carotene beadlet (11.2 g. of 1.2% product) was mixed with 4 ounces of warm tap water and the beadlets dispersed by stirring. The carotene dispersion was added to the ice cream mix at a temperature of 40° F. Vanilla extract (3 ounces) was added, the mix placed in a 10-gallon Emory Thompson freezer and operated for 7 minutes at a 90 per cent overun. The ice cream was then filled into 66 pint containers and frozen at −5° F. The data are shown in Table 6.

The carotene enriched ice cream and the control without carotene were tasted initially and after both storage periods. No differentiation could be made on flavor after manufacture and after 6 weeks of storage. The pleasing creamy color of the carotene-fortified lot of ice cream was noted by members of the taste panel.

Dry cake mix. A commercial white cake mix was fortified with dry β-carotene beadlets and, although the dry mix itself was not colored, the batter and finished cake were colored an even golden yellow. As the first portion of water is added and blended with

TABLE 4

Stability of βcarotene in dried egg yolks

Storage period	Storage temperature (Mg. carotenoids/100 g. yolk)			
	45° F.	75° F.	86° F.	98° F.
Initial	35.2	.....	.....	.....
3 months	35.0	33.0	34.0	33.0
4 months	.....	.....	.....	33.0
12 months	29.2	28.2	31.0	.....

TABLE 5

Stability of β-carotene in frozen egg yolks

Storage period, −5° F.	Total carotenoid content
	(mg./100 g. yolk)
Initial	16.9
3 months	16.5
12 months	15.0

TABLE 6

Stability of β-carotene in ice cream

Ice cream mix

	Carotene content
	(mg./lb.)
Control mix	0.44
Carotene-fortified mix	3.48
Churned and frozen ice cream, initial	3.42
3 weeks' storage at −5° F.	3.36
6 weeks' storage at −5° F.	3.00

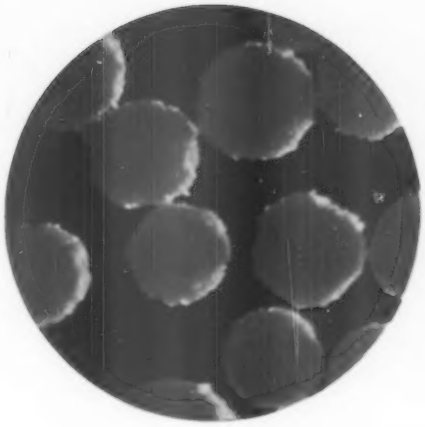


Figure 1. Dry β-Carotene Beadlets, Type 2.4-S, Water Dispersible. Low magnification of 30-80 mesh beadlets with a gelatin-sugar matrix. Characteristic irregular surface may be noted.

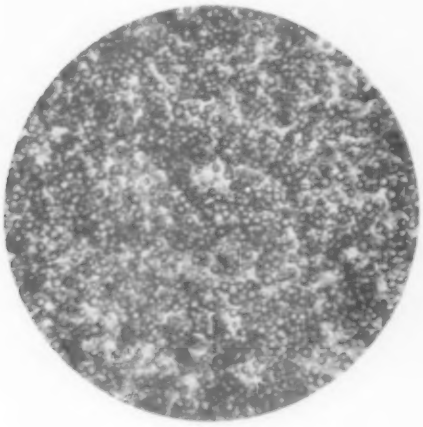


Figure 2. Dry β-Carotene Beadlets, Type 2.4-S, Water Dispersible. High magnification showing emulsified droplets of the oil solution of β-carotene dispersed throughout the gelatin-sugar matrix.

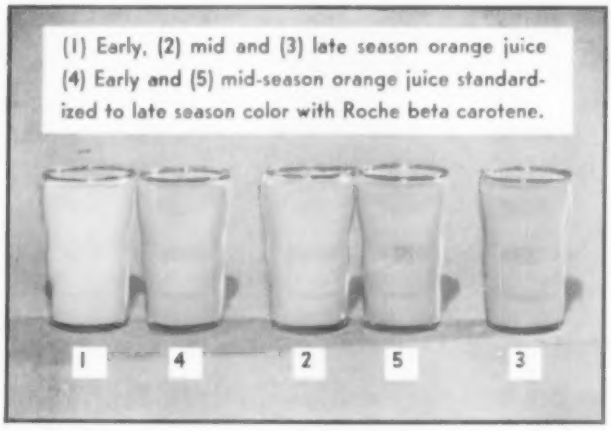
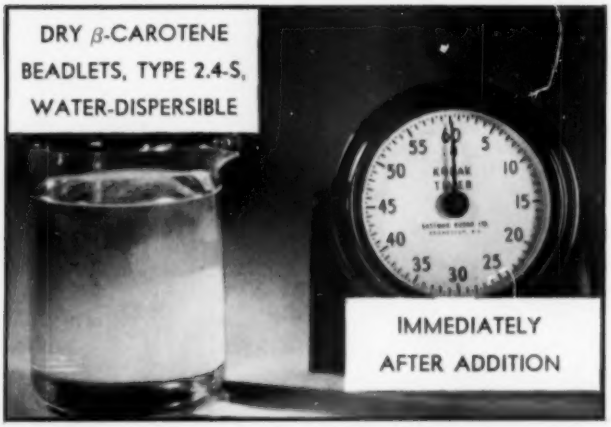
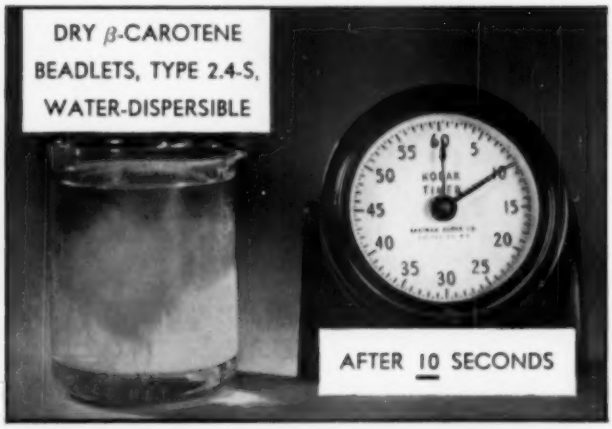

(1) Early, (2) mid and (3) late season orange juice
(4) Early and (5) mid-season orange juice standardized to late season color with Roche beta carotene.
1
4
2
5
3

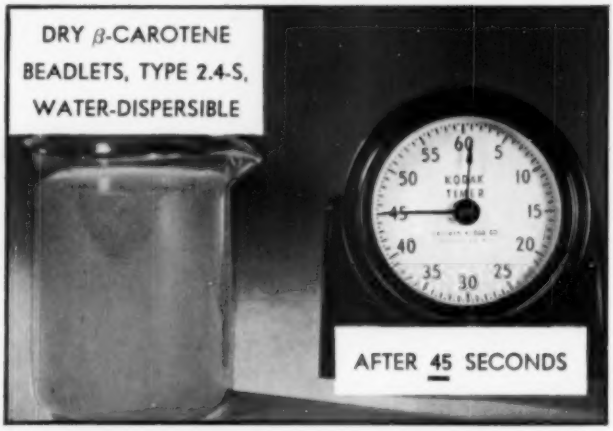
Figure 3. Picture on left shows samples of early, mid-season and late season orange juices from the 1957 Florida season. The low carotenoid early and mid-season juices (glasses 1 and 2) have been brought up to the color of the late season juice (glass 3) by the addition of Dry β-Carotene Beadlets (glasses 4 and 5).

CARBONATED BEVERAGE EXPOSED TO DIFFUSED SUNLIGHT
COLORED WITH ROCHE β-CAROTENE INITIAL
COLORED WITH ROCHE β-CAROTENE 2 MONTHS' EXPOSURE
COLORED WITH FD+C DYES INITIAL
COLORED WITH FD+C DYES 2 DAYS' EXPOSURE

Figure 4. Picture on right illustrates the stability to sunlight of β-Carotene in carbonated beverages containing ascorbic acid. Note the excellent color content of the β-carotene containing beverages on the left compared to the bottles of standard orange coloring beverages on the right.







Figures 5, 6 and 7. These pictures illustrate the rapid dispersion rate of Dry β-Carotene Beadlets, Type 2.4-S in water without stirring. The color as well as the cloud effect simulates the appearance of orange juice.

the fortified mix the color appeared quickly and appeared even throughout.

Five cake layers were fortified to contain 1.8 mg. of β-carotene (3,000 U.S.P. units) per pound of cake and a sixth layer was fortified to contain 3.6 mg. of β-carotene (6,000 U.S.P. units) per pound of cake. The carotene assays on the baked cakes are given in Table 7. The average retention of carotene after baking was 74%. The 1.8 mg./lb. cakes were a light yellow and the 3.6 mg./lb. cake a pronounced yellow.

The stability of the dry β-carotene beadlet in cake mix was investigated by storing fortified samples of

TABLE 7

Retention of added carotene, beadlet form, in cake after baking

Sample	Carotene (mg./lb. of cake) (mg./lb. of cake)	Retention (%)
Cakes colored to contain 1.8 mg./lb.		
Trial 1	1.30	72
2	1.19	66
3	1.35	75
4	1.42	79
5	1.46	81
Cake colored to contain 3.6 mg./lb.		
Trial 6	2.61	73

mix under various conditions. There was no loss of carotene after exposure in open beakers for 42 days at 113° F. or 3 months at room temperature. The stability of the dry β-carotene beadlet in cake mix is therefore excellent.

Miscellaneous application studies. Other investigations revealed that dry β-carotene beadlets can also be successfully used to fortify and color the following types of foods: bread, candy gum drops, cookies, creamed foods, dietetic foods, gelatin dessert, fluid skim milk, pudding, soup mix, whipped cream and toppings.

The experience gained while working with various food products in the course of these investigations has resulted in the establishment of workable levels of β-carotene addition for some food products. As a guide, the following levels of carotene addition are suggested; citrus juices, blends and beverages, 0–10 mg. per liter or quart; mixed liquid egg yolk (to be frozen or dried), 0–50 mg. per lb.; fluid milk (to be made into primary cheese), 0–2 mg. per liter or quart; ice cream liquid mix, 4–10 mg. per 2 lbs. or quart; eggnog, 0–4 mg. per quart; and dry cake mix 3–5 mg. per lb.

SUMMARY

A stable dry form of β-carotene has been prepared which enables the coloring of water-base foods. The development of this form was made possible by the discovery that supersaturated solutions of β-carotene in vegetable oils could be prevented from crystallization by emulsification in a solution of a gellable colloid and converting the emulsion to a dry beadlet form. The resulting dry β-carotene beadlet is readily dispersible in aqueous systems. This relatively high potency form also retains the carotene in a soluble state and stabilizes it against oxidative destruction.

Methods of preparation, physical properties, method of carotene assay, biological value and stability studies are described for the dry β-carotene beadlet.

Studies are presented which demonstrate the successful use of this water-dispersible form of β-carotene in coloring of the following foods: citrus beverages, primary cheese, frozen and dried egg yolk, eggnog, ice cream and dry cake mix. Other uses are mentioned.

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Factors Affecting Storage Stability of Spray-Dried Tomato Powder

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DOMESTIC AND MILITARY DEMANDS for more economical and convenient food preparations in the past few years have started an ever-increasing trend toward preparation of concentrated foods, either partly or completely dehydrated. Such preparations offer worth-while reductions in cost of packaging, shipping, and storing, and frequently offer greater convenience in use.

To satisfy such demands, processes have been developed for the successful production of several fruit-juice powders *(16, 17, 21)* and for tomato-juice powder. The latter product has been prepared by both a vacuum-drying process and a spray-drying process *(8, 9)*. These tomato powders can be reconstituted to a paste of 25% solids or to a juice of 6.5% solids, both having acceptable flavor, appearance, and consistency.

However, not only must the initial quality of such dried products be satisfactory, but also the quality must be reasonably stable during storage. Therefore, after laboratory procedures for producing acceptable spray-dried tomato powder had been developed, early consideration was given to establishing facts concerning its storage stability in respect to container atmosphere and storage temperature. Such a storage study would also make it possible to complete the comparison between vacuum-dried and spray-dried tomato powder.

In respect to the initial quality, the vacuum-dried powder reconstitutes very easily and quickly by stirring the powder into 15 parts by weight of water with a spoon or fork. This reconstituted powder is not significantly different from the paste from which the vacuum-dried powder was made. On the other hand, the spray-dried powder is quite fine and forms sticky, tenacious lumps upon wetting. These must be subjected to vigorous shearing action before a juice of normal appearance and consistency can be obtained. Although the flavor of reconstituted spray-dried powder has been rated quite acceptable, it did not rate as high as the flavor of the vacuum-dried powder. Thus, the ease of reconstitution and the somewhat superior flavor make the vacuum-dried powder more desirable for beverage use.

Nevertheless, it is felt that the spray-dried powder is adaptable for remanufacturing into many tomato products and is suitable for use in prepared dry soups and sauce mixes. Economic considerations also indicate some advantages of the spray-dried powder over vacuum-dried tomato juice powder. First, the cost of producing spray-dried powder would probably be substantially less than the cost of vacuum-dried powder. And, secondly, the package density of the usual spray-dried powder is considerably greater than that of the ordinary vacuum-dried powder. Thus costs for containers, warehousing, and shipping would be much less.

A storage study on the vacuum-dried powder has been reported *(21)* which showed that under proper conditions of packaging the storage stability was quite satisfactory. The stability of the spray-dried tomato powder was subjected to a similar investigation and the results are presented in this paper.

EXPERIMENTAL

Preparation and storage of samples. The spray-dried tomato powder used in this study was produced from a good quality commercially canned paste prepared by a hot-break process. This paste was prepared for and spray-dried according to the procedures described by Lazar *et al. (9)*.

Tomato powder samples from several spray-drying runs were carefully blended and canned, 100 g. per can, in 6-ounce (202 x 314) sanitary-type cans. This blending and canning of more than 1,000 cans for all packs was done in a room having a relative humidity of 5 to 6%. In packs using in-package desiccation (IPD), a desiccant unit (consisting of 10 g. of calcined lime in a sealed packet of double-creped kraft paper) was placed in the can as described by Strashun and Talburt *(21)*, and Talburt, Hendel, and Legault *(22)* before filling in the tomato powder. Nitrogen packing and CO_2 packing were accomplished by evacuating the original air through a small hole, allowing the desired gas to re-enter the can, flushing out this gas by another evacuation and finally refilling the can again with the desired gas and soldering the hole shut. This reduced the oxygen content to less than 0.5%.

Packs of powder (154 cans in each) were canned with air, nitrogen, or carbon dioxide as the can atmosphere. A pack of each was made with and without an in-package desiccant. These packs were subdivided and lots stored at 70° F. (21.1° C.), 90° F. (32.2° C.), and 100° F. (37.8° C.) for selected periods of time. A control pack for sensory appraisal was canned in 29+ inches Hg vacuum with desiccant and stored at −30° F. (−34.4° C.).

METHODS AND DISCUSSION OF OBJECTIVE ANALYSES

Samples were removed from storage at intervals and analyzed for moisture content, O_2 and CO_2 in the can atmosphere, ascorbic acid, soluble color, sulfite content, and lycopene in the tomato powder. Differences in saturation and hue of the color of the reconstituted juices were calculated from values registered by the Hunter Color and Color-Difference Meter.

Moisture (total solids). Moisture was determined by drying 6 to 10 g. of the powder at 64° C. for 16 hours under a pressure of 0.7 mm. Hg. These conditions were adopted after moisture determination with the Karl Fischer method *(13)* gave comparable results.

Moisture determinations are presented in Table 1. Since can atmosphere did not influence the moisture content but desicca-

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TABLE 1

Effect of packaging and storage variables upon the moisture contents and upon components in the headspace gas

Analysis	% Moisture		% O_2 and % CO_2 in can atmosphere[1]							
Storage condition	No I.P.D.[2]	With I.P.D.[2]	No I.P.D.[2]				With I.P.D.[2]			
	Air, N_2 or CO_2	Air, N_2 or CO_2	Air		N_2		Air		N_2	
			% O_2	% CO_2	% O_2	% CO_2	% O_2	% CO_2	% O_2	% CO_2
70° F. (21.1° C.)										
6 Weeks	1.8	0.9	17.0	0.3	0.1	0.0	16.2	0.1	0.0	0.0
3 Months	1.7	0.7	16.3	0.6	0.1	0.1	15.4	0.0	0.1	0.0
6 Months	1.7	0.4	15.6	0.5	0.0	0.2	14.7	0.0	0.0	0.0
9 Months										
12 Months	1.7	0.3	14.5	0.7	0.0	0.4	13.2	0.0	0.0	0.0
90° F. (32.2° C.)										
6 Weeks	1.8	0.5	15.8	0.8	0.0	0.4	15.4	0.0	0.0	0.0
3 Months	1.8	0.2	15.1	1.2	0.0	0.6	13.9	0.0	0.1	0.0
6 Months	1.8	0.1	13.8	1.9	0.1	1.1	12.4	0.0	0.1	0.0
9 Months			12.7	3.2	0.0	1.6	11.5	0.0	0.0	0.0
12 Months	1.9	0.1	11.9	3.4	0.0	2.2	11.0	0.0	0.0	0.0
100° F. (37.8° C.)										
6 Weeks	1.9−	0.3	15.3	1.7	0.1	1.0	14.3	0.0	0.3	0.0
3 Months	1.9	0.1	14.1	3.2	0.1	1.8	12.8	0.0	0.1	0.0
6 Months	1.9+	0.1	11.3	6.9	0.0	4.0	11.3	0.0	0.0	0.0
9 Months	2.2−	0.1	9.8	10.6	0.0	7.4	9.5	0.1	0.0	0.0
12 Months	2.2+	0.1	8.1	14.7	0.0	10.6	8.7	0.0	0.0	0.0

[1] Per cent by volume, % N_2 by difference.
[2] In-package desiccant.

tion did, results have been averaged for all non-desiccated packs and for all desiccated packs. This table shows a considerable increase in moisture content, from 1.7 to 2.2%, in all non-desiccated packs at 100° F. during 12 months' storage.

Since the non-desiccated, inert gas packs had as much an increase in moisture as the corresponding air packs, this increase in moisture did not appear to be dependent upon the presence of oxygen in the can. Such an increase in moisture content during storage occurred in vacuum-dried tomato powder *(24)* and also occurred in dried onions, but not in several other dehydrated vegetables *(10)*. At the lower storage temperatures, 70° and 90° F., the moisture changes were insignificant.

In direct contrast, the moisture contents in all desiccated packs were drastically reduced to very low levels as would be expected. The rate of desiccation increased as the storage temperature increased and the loss was most rapid in the first weeks of storage as has been found in storage studies on other fruits and vegetables *(4, 15, 17, 24)*. The results showed that at 100° F. the average moisture content of the desiccated packs had decreased from 1.8 to 0.7% in one week, to 0.3% in 6 weeks, and to a final level of 0.1% in 3 months. This same final level, 0.1%, was reached in the samples stored at 90° F. in 6 months. At 70° F., the rate of loss was considerably slower, decreasing to 0.3% in 12 months.

CHANGES IN OXYGEN AND CARBON DIOXIDE CONTENT IN CAN ATMOSPHERES

Headspace gas in stored samples was analyzed with an instrument of the Orsat type. Results are presented in Table 1. The most obvious changes during storage were the progressive decrease in O_2 in both air-packs [this decrease being somewhat greater in the desiccated air-pack which might be expected *(10, 24)*], and the increasing production of CO_2 which is apparent in only the *non-desiccated* air and nitrogen packs. These changes (rates and amounts) were, of course, dependent upon the temperature and length of storage. Moreover, the reaction producing CO_2 had a temperature coefficient several times greater than the reaction using up O_2.

An examination of the data indicates the CO_2 contents in the non-desiccated nitrogen packs stored at 100° F. is about two-thirds of the CO_2 contents of the corresponding air-packs. It appears that CO_2 is produced in 2 ways, one reaction which is dependent upon O_2, and the second reaction which is independent of O_2. The second reaction produces much more CO_2 than the first. However, the first reaction is coincident to and may be involved in the production of off-flavors because, as an inspection of Table 5 shows, the non-desiccated inert packs were considerably more stable from the flavor standpoint than either desiccated or non-desiccated air packs.

In contrast to the production of CO_2 in the non-desiccated packs, no CO_2 was present in the can atmospheres of the desiccated packs. The cause for this difference is almost certainly due to the reaction between the desiccant, calcined lime, and the CO_2 which was produced as the powder partially decomposed. This reaction, in fact, between CO_2 and CaO caused such a very marked decrease in CO_2 in the desiccated-CO_2 pack that it was not possible to remove samples of gas large enough to give reliable gas analyses in that pack with the equipment used. Therefore, the gas analyses for this pack are omitted as are those for the non-desiccated-CO_2 pack in which the CO_2 was always 95 to 96% by volume.

ASCORBIC ACID, SOLUBLE COLOR, AND SULFITE CONTENT

The ascorbic acid was determined by modification of the method of Loeffler and Ponting *(12)* as described by Ponting *(18)*.

Soluble color, a measure of non-enzymatic browning, was determined by a variation of the procedure reported by Hendel, Bailey, and Taylor *(5)*. The measurements were made on clarified 2.5% aqueous extracts of the storage samples. The results expressed as optical density, $E^{2.5\%}_{2.0\,cm.}$ 420 mμ, were determined by measuring the absorption of light in an Evelyn photoelectric colorimeter fitted with a 420 mμ filter.

TABLE 2

Influences of storage variable upon ascorbic acid, soluble color, and sulfite content

Analysis	Ascorbic acid[1]						Soluble color[2]						Sulfite content[3]					
Storage condition	No I.P.D.[4]			With I.P.D.[4]			No I.P.D.[4]			With I.P.D.[4]			No I.P.D.[4]			With I.P.D.[4]		
	Air	N_2	CO_2	Air	N_2	CO_2	Air	N_2	CO_2	Air	N_2	CO_2	Air	N_2	CO_2	Air	N_2	CO_2
70° F.																		
6 Weeks	11.1	10.6	11.1	11.1	11.1	11.1	0.33	0.34	0.34	0.35	0.33	0.34						
3 Months	10.5	10.5	10.5	10.7	10.7	10.5	0.34	0.33	0.34	0.35	0.35	0.35						
6 Months	10.7	10.7	10.8	11.0	10.5	10.8	0.32	0.34	0.32	0.34	0.34	0.32						
12 Months	10.2	10.1	10.3	10.2	10.3	10.3	0.34	0.35	0.32	0.34	0.33	0.32						
90° F.																		
6 Weeks	10.4	10.4	10.3	10.9	10.4	10.8	0.34	0.35	0.34	0.34	0.35	0.34	308	316	317	342	328	342
3 Months	10.2	10.1	10.0	10.5	10.5	10.6	0.33	0.35	0.34	0.33	0.34	0.32	280	293	297	289	316	319
6 Months	9.3	9.2	9.4	10.4	10.1	10.5	0.34	0.35	0.36	0.34	0.34	0.32	263	261	266	296	297	285
12 Months	8.9	9.5	9.1	10.5	10.2	10.6	0.41	0.40	0.37	0.35	0.32	0.33	262	258	261	296	329	299
100° F.																		
6 Weeks	9.4	9.9	10.0	10.3	10.5	10.0	0.36	0.35	0.36	0.33	0.35	0.33	268	268	287	303	286	304
3 Months	9.1	9.4	9.2	10.4	10.3	10.5	0.38	0.38	0.40	0.32	0.33	0.35	250	260	268	294	292	287
6 Months	7.8	8.6	8.4	10.9	10.8	10.5	0.48	0.45	0.47	0.34	0.33	0.33	243	226	226	292	292	302
9 Months	6.1	7.1	6.9	10.3	10.4	10.7	0.59	0.56	0.56	0.35	0.34	0.34	218			308		
12 Months	5.2	6.6	5.9	10.9	11.1	10.7	0.69	0.65	0.66	0.34	0.33	0.34	186	203	221	292	290	314

[1] mg. AA/100 g. reconstituted juice (6.5° Brix).

[2] Optical density, $E^{2.5\%}_{2\ cm.}$ 420 mμ = 2 − log G., (G = % transmission).

[3] Sulfite in p.p.m. of tomato powder.

[4] In-package desiccant.

The sulfite content was determined by the Monier-Williams method as described in the A.O.A.C. *(14)*.

Results for these 3 analyses are presented in Table 2. The two obvious points of significance in the table are: (a) in the desiccated packs there were probably only insignificant changes in ascorbic acid, soluble color, and sulfite content during the storage study and (b), in sharp contrast, the non-desiccated packs showed large changes at 90° and 100° F. in 12 months. Thus ascorbic acid decreased by one-half, the soluble color doubled, and the sulfite contents decreased by one-third in 12 months at 100° F. The magnitude of these changes depended primarily upon storage temperature and time. Moreover, it should be noted that these changes were only slightly affected by can atmosphere, being slightly greater in the air-packs than in the corresponding N_2 and CO_2 packs.

The stability of the desiccated packs in relation to these 3 factors is due to the very low moisture content. Previous work *(10, 11, 15, 24)* on storage of dehydrated fruit and vegetable products has shown that decreasing the moisture content to very low levels remarkably decreases the rate of non-enzymatic browning, and the rate of loss of ascorbic acid and of sulfite.

In connection with the non-desiccated packs, a comparison of the data listed in Table 2 with corresponding data given in the study on vacuum-dried tomato powder *(21)* indicated the spray-dried powder to be considerably more stable than the vacuum-dried tomato powder. This is indicated by measurements of soluble color and ascorbic acid.

Two factors may be cited which would cause the rate of soluble color formation to be so much less in the non-desiccated spray-dried powder than in the vacuum-dried powder. First, the initial moisture content of the spray-dried powder was considerably lower, being 1.8% as compared with 2.9% for the vacuum-dried powder. Secondly, the spray-dried powder had been sulfited to the extent of 300 p.p.m. Lowering the moisture and sulfiting are both very effective in decreasing the rate of browning *(10, 11, 15)*.

The reason for the better retention of ascorbic acid in the non-desiccated spray-dried powder than in the vacuum-dried tomato powder is likely due primarily to the very low initial moisture content in the spray-dried powder. However, presence of sulfite in this powder may have aided in stabilizing the ascorbic acid to some extent since it has been reported that sulfite of 800 p.p.m. does stabilize ascorbic acid in powdered dehydrated tomatoes containing 5% moisture when packed and stored under various conditions at room temperature and at 95° F. *(6)*.

COLOR CHANGES

Lycopene. Lycopene, the principal coloring matter in red-ripe tomatoes, was determined by the use of a method developed by Wong and Bohart *(23)* from Zscheile and Porter's procedure *(27)*. Results obtained with samples stored at 100° F. are presented in Table 3. The data show that the lycopene content was stable during 12 months' storage for all packs except for a slight decrease of about 2% in the air packs which occurred within 6 weeks, after which no further change was observed. This decrease is probably due to slight oxidation, as indicated in a study by Cole and Kapur *(2)*.

TABLE 3

Effect of packaging variables during storage at 100° F. upon lycopene stability

Storage conditions	Lycopene[1]					
	No IPD			No IPD		
	Air	N_2	CO_2	Air	N_2	CO_2
100° F.						
6 Weeks	1,212	1,280	1,257	1,222	1,248	1,241
3 Months	1,210	1,251	1,247	1,233	1,253	1,242
6 Months	1,211	1,245	1,229	1,214	1,213	1,233
9 Months	1,220	1,253	1,235	1,228	1,249	1,235
12 Months	1,222	1,227	1,242	1,220	1,233	1,247

[1] Expressed as micrograms per gram of moisture-free powder. Average control value was 1,240 micrograms.

Stability of the lycopene in the spray-dried powder during this study is in sharp contrast to results obtained in the cited study *(23)* on vacuum-dried tomato powder and in Davis' study *(3)* on lycopene in tomato paste before and after storage. In these two studies, there was an apparent increase in the lycopene of 10 to 20% during the storage.

The mechanism for this apparent increase in lycopene during storage is probably due to the nature and properties of lycopene. It should be pointed out that lycopene, $C_{40}H_{56}$, is a polyene compound having 13 double bonds, of which 11 are conjugated double bonds and seven of which can isomerize from the trans-form to the cis-form or visa-versa under the influence of heat or certain catalysts. The tendency for lycopene (which occurs primarily in the all-trans form and which has the deepest red color of all the known isomers) and all its isomers to change from one form to another with the accompanying changes in the absorption spectra has been studied by Zechmeister *et al. (25, 26)*.

It seems possible that during processing of tomato products, the naturally occurring all-trans lycopene isomerizes to the less red partly cisisomers and then during storage these isomers change back to the all-trans lycopene which is the most stable form.

Assuming that such a mechanism may have been true in the cited studies *(3, 23)*, the data in this study indicate that existence of some factor which prevented the reversion of the isomers to the all-trans lycopene. This factor may have been related to the presence of sulfite in the spray-dried powder or related to the spray-drying process.

However, regardless of what may have prevented the recovery of the lycopene, such stabilization of the lycopene content may have been a disadvantage because the data presented by Wong and Bohart *(23)* indicated that recovery of the lycopene during their study may have caused the a/b value (hue, as determined by the Hunter Color and Color-Difference Meter) to stay at a higher level than it would have if there had been no lycopene recovery.

Reflectance measurements of the reconstituted juices. Saturation, hue, and lightness of the color of the reconstituted juices were determined by means of a Hunter Color and Color-Difference Meter *(7)*. One hundred twenty-five ml. of the juices as made up for the sensory appraisal was placed in glass bottom cells of 3½ inches in diameter and the various color attributes measured through the glass with the Hunter instrument using the 2¼ inch aperture in the meter. The color standard employed was a tomato red tile, No. 33, obtained through the courtesy of the Campbell Soup Company. For this tile, the meter was set to read as follows:

$$RD = 7.0, a = +34.0, b = +16.2.$$

The hue of the juices as described by the ratio a/b and the saturation value $\sqrt{a^2 + b^2}$, which is inversely related to the degree of grayness in the color, are presented in Table 4. Data for lightness are not reported since the observations showed that the storage variables had very slight or insignificant effects upon this color attribute.

Apart from minor fluctuations, the hue and saturation of the samples remained the same at 70° F. during 12 months' storage and are not reported, but both of these color attributes in some packs decreased somewhat at 90° and 100° F. during 12 months' storage. The slight change in a/b indicated a shift in hue from red toward yellow in the observed color. The stability of the hue was improved by packing in an inert gas, but desiccation had little effect, as would be expected from results on vacuum-dried tomato powder *(23)*. It should be understood that the maximum difference (0.10) between the higher controls and the samples having the lowest a/b value is so slight that it would perhaps correspond only to a decrease of about 1 unit *(19)* in the Agricultural Marketing Service (AMS) grade for the reconstituted juice.

The decrease in saturation toward a grayer, duller color from the average control for the desiccated samples stored at 100° F. averaged 0.5 unit, whereas for the non-desiccated samples the average decrease was 2.1 units in 12 months' storage. At 90° F. the decreases in saturation were much smaller than at 100° F. Again, the desiccated packs had the greater stability in saturation. Results also indicate that packing in an inert atmosphere may have increased slightly the storage stability of this color attribute.

If the data in Table 4 are examined along with those in Tables 2 and 3, it appears that the changes in hue and saturation in the air-packed samples are not due to changes in soluble color or lycopene. There-

TABLE 4

Influences of packaging and storage variables on Hunter hue and saturation of the reconstituted juices

Color attribute	Hue (a/b)							Saturation ($\sqrt{a^2+b^2}$)						
Storage conditions	Control	No I.P.D.			With I.P.D.			Control	No I.P.D.			With I.P.D.		
		Air	N_2	CO_2	Air	N_2	CO_2		Air	N_2	CO_2	Air	N_2	CO_2
90° F.														
6 Weeks	1.80	1.76	1.78	1.82	1.81	1.79	1.81	37.7	37.0	36.5	37.2	37.4	37.7	37.6
3 Months	1.80	1.80	1.81	1.79	1.80	1.82	1.82	38.2	37.5	37.5	37.5	38.0	38.0	38.1
6 Months	1.79	1.76	1.77	1.78	1.77	1.77	1.78	37.6	37.0	37.3	37.2	37.2	37.5	37.6
12 Months	1.75	1.73	1.76	1.76	1.72	1.73	1.74	37.3	36.3	36.7	36.5	36.9	36.7	36.8
100° F.														
6 Weeks	1.79	1.79	1.81	1.80	1.78	1.80	1.79	38.0	37.3	37.8	37.6	38.0	37.8	38.0
3 Months	1.79	1.77	1.79	1.80	1.76	1.78	1.81	37.6	36.9	37.4	37.2	36.6	37.5	37.6
6 Months	1.80	1.76	1.80	1.79	1.78	1.77	1.79	37.5	36.6	36.6	36.7	37.2	37.2	37.4
12 Months	1.75	1.70	1.74	1.70	1.72	1.74	1.77	37.6	35.3	35.8	35.6	37.0	37.1	37.5

fore, it seems that an unknown factor or factors must be causing the changes in the reflectance data. This unexplained non-relationship between the chemical data and reflectance data is even more apparent in the study on vacuum-dried tomato powder *(23)* where the changes in hue during storage were several times greater with slight, if any, changes in soluble color and only very slight decreases in lycopene content after the first 6 weeks of storage.

The hue of the spray-dried powder appears to be considerably more stable than the hue of the vacuum-dried powder *(23)*. Since the decreases in hue do not seem to be related to increases in soluble color, the presence of sulfite does not seem to explain the apparent superior stability in respect to hue of the spray-dried powder over that of vacuum-dried tomato powder.

METHODS AND RESULTS OF SENSORY APPRAISAL

Flavor. Judgments of flavor were made by presenting to the test panel a series of samples which had been stored for the same period and temperature. Each series of 7 samples which included a hidden control (vacuum-desiccated pack held at −30° F.) and samples of powder stored in each of the three can atmospheres with and without desiccant were ranked against a labeled control. The experimental plan, a balanced incomplete block design, for this appraisal was plan 11.8 of Cochran and Cox *(1)*, which provides for 7 appraisal sessions of 4 samples each, making possible 4 replications of each sample. A labeled control was used in every session as a reference and a coded hidden control of the same material was used in 4 of the 7 sessions.

The samples of tomato powder were reconstituted in a blender with cold water to a smooth paste which was diluted to a juice of 6.0° Brix. Twenty-ml. portions of the cooled juices at 55° to 65° F. were served in 1½-ounce paper cups in appraisal booths (lighted with 25-watt blue lights to mask the red color of the juice) to a panel of 12 trained judges. The 4 coded juices were ranked 1 to 4, Rank 1 being most nearly like the labeled control and Rank 4 the least like the labeled control.

Analyses of variance of judges' average ranks and Scheffé least significant differences *(20)* were used to interpret effects of treatments.

Results of the flavor appraisal given in Table 5 is briefly summarized as follows:

1. Off-flavors developed very quickly during storage of air-packed powder. Even at the lowest storage temperature, 70° F., significant off-flavors had developed within 6 weeks. The off-flavor was characterized as "hay", "grassy", "scorched", or "oxidized", and it seemed to become progressively worse during storage.

2. Flavor stability was improved considerably by inert gas packing. Thus, the non-desiccated inert gas packs were not significantly different at the 5% level from the controls in 12 months at 70° F. Even at 90° and 100° F., they were not significantly different from the control for 6 weeks to 3 months.

3. As expected, the inert gas packs with IPD had the best flavor stability *(10, 24)*. Such packs even at 100° F. were not significantly different in flavor from the controls after 12 months of storage.

4. There were no consistent differences between corresponding nitrogen and carbon dioxide packs.

A comparison of the flavor appraisal data for certain packs in Table 5 with the data for the same corresponding packs of vacuum-dried tomato powder as listed in Table 3 of the article by Wong, Dietrich, Harris, and Lindquist *(24)* indicated the storage stability in respect to flavor changes of the spray-dried powder to be considerably better than the storage stability of the vacuum-dried powder. This indication of superior storage stability in respect to flavor may be due to the lower initial moisture content and the presence of sulfite in the spray-dried powder.

If the data in Tables 2 and 5 are examined together, it can be seen that significant off-flavor developed in less than 6 weeks at 70° F. in the air-packs, but that little or no change in soluble color occurred even in

TABLE 5

Changes in sensory evaluations of flavor and color of the reconstituted juices due to packaging and storage variables

Sensory appraisal	Flavor[1]							Scheffé[5] L.S.D. at 5% level	Lightness of color[2]							Scheffé L.S.D. at 5% level
Storage conditions	Control	No I.P.D.			With I.P.D.				Control	No I.P.D.			With I.P.D.			
		Air	N_2	CO_2	Air	N_2	CO_2			Air	N_2	CO_2	Air	N_2	CO_2	
70° F.																
6 Weeks	3.1	5.1	3.8	3.1	5.8[3]	3.4	3.7	2.2	.....	.....	.....	.....	.....	.....	.....	.....
3 Months	3.1	5.7[3]	4.0	3.6	5.2[3]	3.5	2.8	1.9	.....	.....	.....	.....	.....	.....	.....	.....
6 Months	3.2	5.6[3]	4.0	3.7	5.4[3]	3.2	2.8	1.9	.....	.....	.....	.....	.....	.....	.....	.....
12 Months	4.0	5.3	3.6	4.3	5.0	3.0	2.8	2.0	.....	.....	.....	.....	.....	.....	.....	.....
90° F.																1.3
6 Weeks	3.1	5.4[3]	4.0	4.9[3,4]	4.8[3]	2.9	2.9	1.7	4.5	5.2	2.5[3,4]	2.6[3,4]	4.3	4.4	4.4	1.6
3 Months	2.7	5.7[3]	4.2[4]	5.0[3,4]	5.6[3]	2.5	2.4	1.7	4.5	3.2	2.8[3]	4.5	4.7	3.8	4.5	1.5
6 Months	3.1	5.5[3]	4.5[4]	4.7	4.5	2.5	3.2	1.8	4.0	3.5[4]	3.3	2.7[4]	5.2	3.9	5.5[3]	1.3
12 Months	2.6	6.2[3,4]	3.8	4.6[3]	4.0	3.1	3.7	1.8	5.0	2.7[3,4]	3.3[3,4]	2.8[3,4]	4.9	5.0	4.3	
100° F.																1.7
6 Weeks	2.8	5.2[3]	4.4	4.0	4.8	3.4	3.4	2.2	4.4	4.9	2.6[3]	3.7	4.4	3.6	4.4	1.8
3 Months	3.0	5.6[3]	4.5	4.6[4]	4.8[3]	2.8	2.7	1.8	4.3	4.0	4.0	2.7[4]	3.9	4.5	4.7	1.4
6 Months	2.6	5.6[3]	4.3	5.4[3,4]	3.8	2.8	3.5	1.9	4.2	3.6[4]	1.5[3,4]	3.4[4]	5.6[3]	5.0	4.8	1.6
12 Months	2.0	6.1[3,4]	5.4[3,4]	5.3[3,4]	3.5[3]	3.0	2.6	1.4	5.5	2.8[3,4]	2.3[3,4]	2.3[3,4]	5.0	4.9	5.3	.....

[1] Rank 1 = flavor most like control. Rank 7 = flavor most different from control.
[2] Rank 1 = darkest color. Rank 7 = lightest color.
[3] Significantly different from control at 5% level.
[4] Significantly different from desiccated pack having same atmosphere and storage conditions.
[5] Least significant difference by Scheffé method *(20)*.

12 months at 70° F. in the air-packs. This fact may indicate that development of off-flavors in these tomato powder samples did not depend upon an increase in soluble color unless an insignificant increase in such color can produce significant amounts of off-flavor. In contrast, with some dehydrated vegetables, considerable browning occurs before the off-flavor is considered objectionable *(10)*.

Color. The judges who had ranked the flavor also ranked 3 attributes of color: lightness (dark to light), hue (red to orange), and saturation (pale or grayish to vivid). Samples of the juices were put into 50-ml. crystallizing dishes which were filled to the brim. A separate set of such coded dishes for each color attribute judged was placed in a color booth. The dishes in each set were placed in random order with the codes to the back. The judges ranked them 1 to 4—1 being given to the darkest, to the reddest, and to the most saturated, and 4 being given to the lightest, to the most orange, and to the least saturated. The experimental design and the statistical analyses were the same as for the flavor appraisal. No labeled controls were used.

This color appraisal indicated that the panel could find no significant difference in saturation amongst the samples for any storage temperature or time. Nor were significant differences found in lightness or hue at 70° F. At 90° and 100° F., some significant differences were detected in the samples. However, since the significant differences in the samples for hue coincided more or less with those found for lightness, only the results for lightness of samples at 90° and 100° F. are presented in Table 5. Although this table shows some random inconsistencies, in the main, none of the desiccated packs were ever significantly darker than the controls whereas the inert non-desiccated packs became significantly darker than the controls very early in the storage study. In contrast, the non-desiccated air packs at first were as light as the controls but gradually darkened until at 12 months they were significantly darker than the controls. This would seem to indicate that some factor other than the formation of soluble color was affecting the lightness of the non-desiccated samples.

In regard to the effect of the two inert atmospheres on lightness, there was no significant difference between the two packs when both were desiccated or both non-desiccated.

A comparison of results obtained by means of the Hunter Color and Color-Difference Meter with those results obtained by means of the sensory appraisal show two anomalies: first, saturation by the reflectance meter decreased significantly for the non-desiccated samples, especially after 12 months at 100° F. On the other hand, the appraisal panel did not detect significant differences in saturation among the samples for any storage temperature and period. Secondly the reflectance meter indicated very little, if any, change in lightness of the juices during the study but, in contrast, the sensory panel found a considerable number of significant differences in lightness between the non-desiccated and the desiccated samples.

Assuming that the results obtained with the reflectance meter were correct, it appears that the appraisal judges interpreted actual differences in saturation as differences in lightness.

SUMMARY AND CONCLUSIONS

The data show that spray-dried tomato powder can be stored for 12 months at 100° F. when the powder is packed with a desiccant and canned in an inert atmosphere. Under such conditions, production of off-flavors, loss in ascorbic acid or sulfite, and change in soluble color were insignificant.

High moisture levels, presence of O_2, and storage temperatures of 90° F. or higher were factors found to be detrimental to storage stability. Thus, if O_2 were eliminated from the can atmosphere by replacing with an inert gas, a moisture content of 1.8% (and perhaps higher) could be tolerated at 70° F. for long periods of time. In contrast, at the higher temperatures of 90° and 100° F., it was necessary to reduce the moisture content with an in-package desiccant, as well as to pack in an inert atmosphere in order to get reasonable storage stability in respect to flavor, soluble color, and ascorbic acid retention.

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Methods to Extend Storage of Fresh Vegetables Aboard Ships of the U. S. Navy[a,b]

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Object of these tests was to develop practical methods to extend the length of time fresh, salad-type vegetables can be kept in usable condition under shipboard conditions. Although canned, dehydrated and frozen vegetables are adequate for providing calories and vitamins, a menu soon becomes monotonous unless supplemented by some items that can be served in a fresh raw state.

In order to keep fresh vegetables in good condition during long voyages or to have them in acceptable condition when issued by supply ships, it is necessary to retard spoilage and deterioration of quality. It also is desirable to reduce the bulk and spoilage to make the best use of the limited refrigerated storage space on ships.

Commercial storage experience with fresh vegetables cannot be applied directly to the ships-supply problem. The figures for safe commercial storage allow for a marketing period after removal from storage and also are aimed at disposing of the vegetables while they are still in marketable condition. Since vegetables in ships supplies are used within a few hours after being removed from refrigeration they can be stored longer. Part of the vegetables may be retained in storage even after appreciable spoilage has developed as long as a reasonable amount can be salvaged by trimming.

MATERIALS AND METHODS

Vegetables studied in these tests were cabbage, celery, lettuce and tomatoes, all of which may be used to prepare raw salads. Tests have been conducted for 3 years to obtain information on the storage behavior of these vegetables from different production areas and in different seasons. The vegetables were purchased on the Washington, D. C. wholesale market and were shipped to Washington as part of commercial loads.

Cabbage, celery and lettuce were stored as received or were

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[b] Presented at the Sixteenth Meeting of the Institute of Food Technologists, June 13, 1956, St. Louis, Missouri.

trimmed and repacked before storing. In some tests part of the vegetables were stored in crates or cartons with polyethylene liners or the lettuce heads and celery stalks were packed individually in polyethylene bags.

In most tests the cabbage, celery and lettuce were stored at 38° F., as representative of the temperature used for vegetables on shipboard, and at 32° F., the optimum temperature for long storage life of these vegetables. Recently, storage at 45° F. has been added since some ships maintain their chill box at temperatures that high.

Samples of the cabbage, celery and lettuce were removed from each storage temperature at intervals of one or two weeks for up to eight weeks, trimmed of all waste caused by decay, wilting or discoloration and weighed to determine the amount that remained edible after various storage periods.

Tomatoes were obtained in the mature green stage, stored at 38° F. or ripened at 55° or 65° F. and then stored at 32° or 38° F. The degree of ripening and amount of waste from decay were determined at the end of the ripening period and at intervals during storage.

RESULTS AND DISCUSSION

Cabbage. Data (Table 1) from these tests show that there is almost as much edible cabbage after 8 as after 4 weeks in storage and that there was no consistent difference between 32° and 38° F. even after 8 weeks. Late cabbage (the lots from New York) kept much better than early cabbage.

TABLE 1

Storage life of cabbage at 32° and 38° F.

Origin and date stored	Storage temperature (° F.)	Per cent of cabbage edible after storage for		
		4 weeks	6 weeks	8 weeks
New York (11-15-54)	32	82	76	72
	38	83	79	80
New York (10-14-55)	32	87	79	87
	38	87	85	84
South Carolina (2-16-55)	32	73	69	72
	38	75	67	66
South Carolina (5-19-55)	32	62	68	70
	38	66	67	65
Pennsylvania (7-22-55)	32	74	74	73
	38	77	74	70
Average:	32	76	73	75
	38	78	74	73

Although there was no consistent difference in amount of edible cabbage at the two storage temperatures after 8 weeks, the quality was better at 32° F. Very little abscission of the leaves occurred at this temperature and the heads remained fresh and turgid for the entire storage period. At 38°, leaves turned yellow and abscissed readily, and the outer ones became wilted and dry.

Bacterial soft rot was inhibited until the 6-week inspection but was general on the outer leaves at both storage temperatures at the 8-week inspection. Black leaf speck, a physiological disorder, was important in some lots and was more severe at 32° than at 38° F.

Celery. In tests with celery packed in regular unlined commercial crates (Table 2) there was more edible celery in all tests after storage at 32° F. than at 38° or 45° F. The amount of edible celery decreased as the storage period lengthened. Deterioration was more rapid at 38° than at 32° F. and was very rapid at 45° F. These data show a definite advantage in storing celery at 32° instead of 38° or 45° F., the storage temperatures on some ships. After 8 weeks' storage in unlined crates there was an average of 18% more edible celery at 32° than at 38° F. None remained at 45° F. after 8 weeks, and less than half was edible after only 6 weeks. There was almost as much edible celery after 8 weeks at 32° as after only 6 weeks at 38° F.

TABLE 2

Storage life of celery in lined and unlined crates and individual polyethylene bags

Kind of pack	Storage temperature (° F.)	Percentage of edible celery after		
		3–4 weeks	5–6 weeks	7–8 weeks
Unlined crates	32	97	89	79
	38	93	83	61
	45	83	41	....
Individual polyethylene bags	32	97	92	84
	38	92	80	66
	45	84	45	....
Crates lined with polyethylene	32	96	94	89
	38	95	87	76
	45	79	53	....

Average of 5 tests.

Color and crispness were retained longer at 32° F. than at the higher temperatures. For example, after 4 weeks, celery at 32° F. was as green as when stored, whereas at 45° F. the outer leaf stalks were almost completely blanched and the inner stalks were a very pale green. The color at 38° F. was intermediate.

Celery packed in individual polyethylene bags or in polyethylene lined crates keep better than celery in unlined crates at all temperatures. The beneficial effect of the polyethylene bags and liners was especially noticeable at the last inspection at each temperature. Yellowing was considerably less in polyethylene lined crates and bags than in unlined crates after 4 and 6 weeks at 38° F. and the green color was usually retained up to 8 weeks at 32° F.

Lettuce. In tests with trimmed and untrimmed lettuce stored in regular, unlined cartons (Table 3) the lettuce kept considerably better at 32° F. than at 38° and much better at 38° than at 45° F. during 6 weeks' storage. Advantages of the lower temperature increased with increase in length of storage. It is interesting that there was about as much edible lettuce after 6 weeks at 32° as after only 4 weeks at 38° F. and as much after 4 weeks at 32° as after only 2 weeks at 38° F.

TABLE 3

Storage life of trimmed and untrimmed lettuce stored at 32°, 38° and 45° F. in unlined cartons

Storage temperature (° F.)	Preparation of lettuce before storage	Percentage of edible lettuce after		
		2 weeks	4 weeks	6 weeks
32	Untrimmed	69	61	53
	Trimmed	88	83	77
38	Untrimmed	62	51	42
	Trimmed	82	71	57
45	Untrimmed	54	24	....
	Trimmed	77	52	....

Average of 4 tests.

Lettuce that was trimmed before storage kept much better at all temperatures than untrimmed lettuce and resulted in approximately 40% more edible lettuce per unit of storage space or, in effect, increased the storage capacity.

In tests with lettuce trimmed and packed in polyethylene lined and unlined cartons and individual polyethylene bags after shipment (Table 4) there was, in general, no difference in the amount of edible lettuce in the various storage packages. However, lettuce packed in polyethylene was consistently better in quality and appearance than lettuce in unlined cartons as it retained green color better and did not wilt. Polyethylene liners and bags were about equal in their effect on amount of edible lettuce and appearance.

TABLE 4

Storage life of lettuce trimmed after shipment by rail and packed in unlined cartons and polyethylene bags or polyethylene lined cartons

Storage temperature (° F.)	Kind of package	Percentage of edible lettuce after		
		2 weeks	4 weeks	6 weeks
32	Unlined cartons	92	78	73
	Lined cartons	90	82	69
	Polyethylene bags	90	81	70
38	Unlined cartons	86	74	52
	Lined cartons	88	76	53
	Polyethylene bags	86	68	53

Average of 4 tests.

Tomatoes. Mature-green U. S. No. 1, commercially-packed, Florida tomatoes that had been 4 to 6 days in transit at moderate temperatures were used in these tests which were repeated three times. Approximately 80 to 85% were firm ripe after 12 to 14 days at 65° F. or 28 days at 55° F. Mature-green tomatoes stored at 38° F. did not ripen in 20 days and all developed Alternaria rot instead of ripening within 5 days after being transferred to 65° F.

In these tests if tomatoes were ripened at 65° F. and then stored at 32° or 38° F. a large proportion remained edible for a total of 42 days (Table 5). There was less decay at both 32° and 38° in the tomatoes that had been ripened at 65° than in those ripened at 55° F.

TABLE 5

Usable life of tomatoes if ripened at 65° or 55° F. and stored at 32° or 38° F.

Ripening		Storage		Total period	Condition of tomatoes after storage	
Temp.	Time	Temp.	Time		Edible	Decayed
(° F.)	(Days)	(° F.)	(Days)	(Days)	(%)	(%)
55	28	32	15	43	85	15
		38	15	43	79	21
65	12	32	30	42	97	3
		38	30	42	84	16

Results from these tests indicate that fresh tomatoes can be kept under refrigeration at 32° or 38° F. on board ship for about 2 weeks if ripened to a firm ripe condition at 55° before loading and 3 to 4 weeks if ripened at 65° F. If the tomatoes can be ripened at 55° or 65° F. after loading and then transferred to 32° or 38° F., their availability might be extended to 6 weeks. Although still reasonably good in appearance and edible, a considerable number of the tomatoes ripened at 65° and stored at 32° and 38° F. were soft after 42 days. In all cases tomatoes ripened and stored 42 days should be used within a few hours after they are removed from storage. Tomatoes stored at 32° F. after ripening kept better than those stored at 38° F.

CONCLUSIONS

These tests demonstrate that refrigerated storage space can be conserved, storage life of cabbage, celery and lettuce considerably extended, and quality maintained by using lower storage temperatures than now are generally used for ships supplies. They also demonstrated that fresh tomatoes could be kept on board ship for 3 to 4 weeks without excess spoilage if mature green tomatoes are ripened at 55° or 65° F. before loading and then stored at 32° or 38° until used or for 6 weeks if ripened at 55° or 65° F. after loading and then transferred to 32° or 38° F.

Effect of Individual Curing Ingredients on the Shelf Stability of Canned Comminuted Meats*

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(Manuscript received April 24, 1958)

SHELF STABILITY of canned cured meat products is a perplexing anomaly. Most of these items receive thermal processings far below those applied to other low acid products. Canned vegetables, such as peas, are prone to spoilage if they are not given a cook equivalent to about 3 minutes at 250° F.—expressed as $F_o = 3$. Cured meat products become totally inedible if subjected to that degree of processing. Indeed, severe organoleptic degradation occurs well below $F_o = 1$. Subculture of shelf stable cured meats reveals small numbers of viable aerobic and anaerobic spores. Despite the relative ease with which these spores can be demonstrated in finished product, the industry has enjoyed a long history of satisfactory commercial production.

The most obvious explanation for stability lies in the inhibitory effect of curing salts, NaCl, $NaNO_3$, and $NaNO_2$, which are an integral part of these products. However, a survey of the literature which has been built up over the last half century leads one to the conclusion that no reasonable concentration of a single curing salt or combination thereof will prevent completely the growth of *Clostridium botulinum* and other spore forming bacteria *(6, 7, 15, 16, 17, 18, 19, 20, 21)*.

It was our purpose to carry out studies to determine the factors responsible for the stability of lightly processed cured meats. Experimental procedures used were dictated by three primary considerations.

1. Virtually without exception, thermal processings used in the preparation of canned cured meats vary little among commercial producers. As has been indicated above, organoleptic requirements limit thermal processing to values well below spore lethality.

2. Salt concentrations are governed primarily by organoleptic considerations—levels above 3.5% in cured meats are often judged "over salty" by the consumer. Henceforth in this presentation, salt levels will be designated as "per cent brine"—i.e. the percentage of salt in the water phase of the meat emulsion. The bacteriostatic effect of salt in food products is generally believed to be inversely proportional to moisture level *(12)*. Analysis of commercial cured meat items showed a brine content ranging from 3–6%.

Nitrite and nitrate maxima are determined by Federal regulation *(14)*.

3. Ayers *et al. (1)* and Burke *et al. (5)* have demonstrated that a very low level of putrefactive anaerobic spores is present in commercial meat trimmings. Brown *(4)* and Harriman *et al. (11)* have also confirmed this finding; similar results were obtained in a year-long survey at Swift's Chicago Plant.

Studies on the stability of cured meats have often involved packs heavily inoculated with spores of *Cl. botulinum* and other putrefactive anaerobes showing especially high orders of heat resistance.

In view of the fact that previous investigations on the role of curing ingredients have in almost every case involved the use of heavily inoculated product as test material, combined with the observation that the conclusions reached on the basis of these studies is in contradiction to the observed history of the product, it seemed that a rational approach would involve product contaminated only with the indigenous flora. For the purpose of confirming conclusions reached on the bases of uninoculated packs, inoculated material was studied with close attention to the spore levels used. As will be indicated subsequently, the key to the interpretation of these results is, in fact, the level of meat contamination with spores.

MATERIALS AND METHODS

Meat emulsions composed of typical packing house beef and pork trimmings were stuffed in 300 x 308 cans and cooked in commercial retorts. Penetration data, obtained by means of geometrically centered copper constantan thermocouples, were calculated according to methods described by Ball *(2, 3)*.

All cans were incubated at 100° F. and observed each working day for evidence of spoilage. Routinely, spoiled cans were opened and examined organoleptically as well as bacteriologically to determine the nature of spoilage. Putrid swells were defined as cans in which there was any indication of putrefactive anaerobic development, as evidenced by organoleptic and bacteriological analysis of swollen cans.

Inocula used in the confirmatory experiments consisted of *Clostridium* species *P.A. 3679–29* grown in Anderson pork pea medium.

Determination of viable putrefactive anaerobic spores was accomplished by means of 3 tube most probable number analysis in liver infusion broth. Aerobic organisms were enumerated via direct plating on tryptone glucose extract agar.

RESULTS

Results obtained from pilot plant scale tests indicated that within organoleptically acceptable limits of salt and permissible levels of nitrate and nitrite, the key to the stability of lightly processed cured meats is nitrite. Table 1 summarizes the spoilage results on a pack which received an $F_o = 0.08 - 0.13$ in 300 x 308 cans. It will be noted that salt (brine) effected no increase in stability of the product over the controls containing no added salt. This failure to increase stability as a result of increasing brine concentration within organoleptically acceptable levels is seen both in the presence and in the absence of nitrate. The nitrate at both levels of brine failed to produce

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TABLE 1

Effect of individual curing ingredients on the shelf stability of canned meat. F_o: 0.08 − 0.13

Cure	Total cans packed	Non-putrid swells	Putrid swells	Sound cans	Percentage of pack sound
5% Brine	12	4	0	8	67%
5% Brine + Nitrate[1]	12	11	0	1	9%
5% Brine + Nitrite[2]	12	0	0	12	100%
5% Brine + Nitrate + Nitrite	12	0	0	12	100%
3.5% Brine	12	6	0	6	50%
3.5% Brine + Nitrate	12	9	2	1	9%
3.5% Brine + Nitrite	12	0	0	12	100%
3.5% Brine + Nitrate + Nitrite	12	0	0	12	100%
0 Control	12	3	0	9	75%

[1] Sodium nitrate concentration: 156 p.p.m.
[2] Sodium nitrite concentration: 78 p.p.m.

a stable product; on the contrary, presence of nitrate apparently enhanced spoilage in general, and as seen in the variable containing the lower level of brine, 2 of the 12 cans showed putrid spoilage, despite the presence of nitrate. Variables containing nitrite, either in the presence or absence of nitrate, were completely stable at both brine levels.

The effect of nitrite is a function of concentration. The experiments reported in Table 1 involved sodium nitrite added at a level of ¼ ounce per hundred pounds of meat (78 p.p.m.). Data in Table 2 indicate that a level of 39 p.p.m. is not sufficient to prevent spoilage. Further, this pack gave indication of a stimulation effect of nitrate on spoilage organisms and the failure of this agent to inhibit the growth of putrefactive anaerobes. The data fail to reveal any useful function played by nitrate; nitrite must be present in adequate concentration to assure a shelf stable product. The nitrite and nitrate levels shown were those of the concentrations present in the meat emulsion prior to thermal processing. It will be recalled that nitrite is extremely reactive with protein materials and is likewise quite labile to heat; in contrast, nitrate is relatively inert and is not destroyed by heat. Hence, the residual nitrite in the processed meat is far lower than the added levels, whereas the nitrate concentrations in the finished product approximate those in the unprocessed emulsion. Usually, analysis of finished product to which 78 p.p.m. of sodium nitrite has been added before processing, will show between 10 and 20 p.p.m. residue after retorting.

It will be noted that a distinction has been made between putrid and non-putrid spoilage. This is based on the premise that any product allowing the development of putrefactive anaerobes is presumptively one which will allow growth and toxin development by *Cl. botulinum*. Table 3 summarizes data which indicate that sodium nitrite, at a level of 78 p.p.m., is an effective inhibitor of putrefactive anaerobes. The results shown represent a tabulation from a number of experiments similar to those cited in Table 1 and 2. Statistical analysis on the data yielded a Chi Square = 6.37, assuming one positive putrid ran in the series containing 78 p.p.m. of sodium nitrite. This indicates a probability of 98–99% that the apparent inhibition of putrefaction is not due to chance.

TABLE 3

Effect of 78 p.p.m. $NaNO_2$ on putrefactive spoilage in canned meat containing 3.5% brine

	With 78 p.p.m. $NaNO_2$/cwt.	Without 78 p.p.m. $NaNO_2$/cwt.
Cans packed	96	131
Putrid swells	0	13

Chi square: 6.37.
% Reliability: 98–99%.

These results are contingent upon a certain level of heat injury to the spores indigenous to this environment. Rapid spoilage occurs in product containing the same levels of curing ingredients but which has undergone a "pasteurizing" cook (155° F.). However, in a 235° F. retort, growth-restricting injury occurs somewhere below $F_o = 0.10$ in a 12 oz. container.

Stability is further dependent upon the contamination level of the raw product. Putrefactive anaerobic spore loads range up to a maximum of approximately 1 per gram. Apparently, fresh meat trimmings, rich in readily available organic materials and possessive of a very low O-R potential, tend to favor germination of indigenous P.A. spores. Artificial inoculation with large numbers of spores results in prompt failure of the system. As can be seen in Table 4, ⅔ of a pack containing 3.5% brine, 78 p.p.m. $NaNO_2$ inoculated with 15,000 P.A. spores per gram and retorted to an $F_o = 0.13$, had developed putrefactive spoilage within 45 days at 100° F. This is in sharp contrast to data reported in Tables 1 and 2 wherein the same curing and processing produced shelf stability when only indigenous spores contaminated the product. Table 4 also reveals that the presence of 156 p.p.m. sodium nitrate failed to change the rate of putrefactive spoilage.

It has previously been mentioned that small numbers of viable aerobic and anaerobic spores can be demonstrated in

TABLE 4

Putrefactive spoilage of cured meats inoculated with 15,000 P.A. spores per gram

$F_o = 0.13$

Cure	45 days incubation at 100° F.	
	Total cans packed	Putrid swells
3.5% Brine + 78 p.p.m. $NaNO_2$	100	66
3.5% Brine + 78 p.p.m. $NaNO_2$ + 156 p.p.m. $NaNO_3$	100	64

TABLE 5

Survival of P.A. 3679 in luncheon meat containing 3.5% brine, 78 p.p.m. $NaNO_2$/cwt., processed to $F_o = 0.10$

	PA 3679
Added per gram	2.0
Indigenous P.A. spores	0.63
Total Viable P.A. spores/gm.	
Raw	2.63
Cooked	0.54
P.A. spore survival	20.5%
Cans incubated 100° F.	80
Cans sound: 90 days	80

TABLE 2

Effect of curing ingredients on shelf stability of canned meat containing 3.5% brine

Cure	$F_o = 0.08$				$F_o = 0.13$			
	Total cans in pack	Non-putrid swells	Putrid swells	% of pack sound	Total cans in pack	Non-putrid swells	Putrid swells	% of pack sound
156 p.p.m. nitrate	8	7	0	13%	8	7	0	13%
78 p.p.m. NO_2, 39 p.p.m. NO_3	8	6	1	13%	8	5	1	25%
156 p.p.m. NO_3, 78 p.p.m. NO_2	8	2	0	75%	8	0	0	100%
78 p.p.m. NO_2	16	0	0	100%	16	0	0	100%
No nitrite or nitrate	32	25	6	3%	32	23	3	22%

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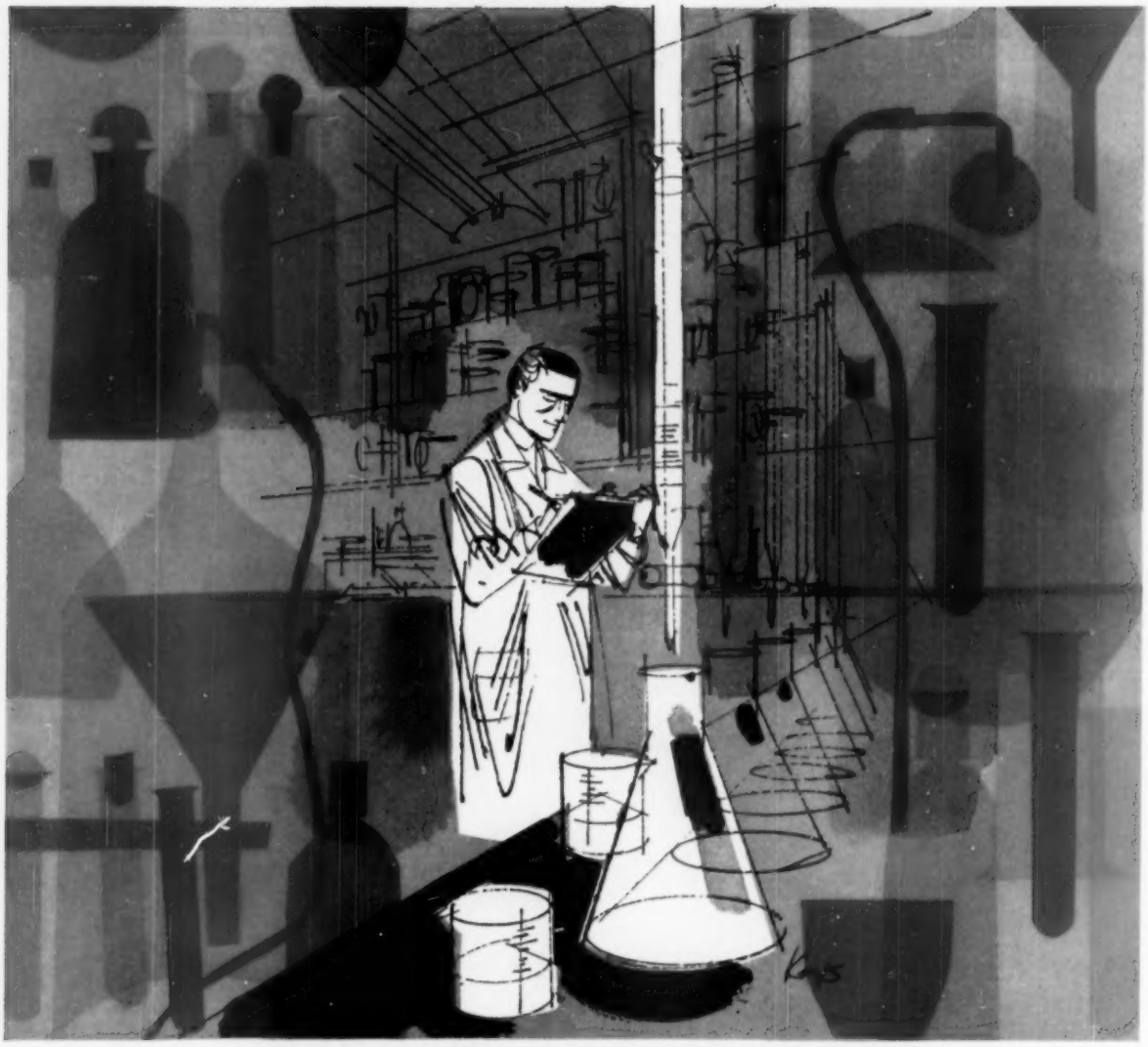

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shelf stable commercial product. This strongly indicates that the primary effect of nitrite is an inhibition of germination and/or outgrowth of heat injured spores. Recalling that Gross, Stumbo and Vinton *(8)* showed that an $F_r = 6$ was required to destroy completely a concentration of 5 *P.A. 3679* spores per gram in luncheon meat, we decided to confirm our results in packs inoculated with low concentrations of putrefactive anaerobic spores. An emulsion was prepared containing 78 p.p.m. sodium nitrite and 3.5% brine and processed to $F_r = 0.10$. The pack was inoculated with 2 *P.A. 3679* spores per gram. Analysis of the product before inoculation, after inoculation, and subsequent to retorting, showed that at least 20% of the P.A. spores survived processing. This pack gave no evidence of spoilage during a 90-day incubation period at 100° F. Bacteriological analysis revealed no growth of spores surviving processing. This suggested that the putrefactive anaerobic spores not destroyed by the mild heat treatment suffered injury sufficient to prevent their outgrowth during incubation.

DISCUSSION

The shelf stability of canned cured comminuted meats represents an area where a fortuitous combination of circumstances produces a protective result. In this type of product, a surprising degree of shelf stability is imposed by sub-lethal heat treatment combined with organoleptically acceptable levels of salt and concentrations of sodium nitrite which fall within legal limits. Although it is apparent from the experimental results that addition of 78 p.p.m. sodium nitrite to meat emulsions resulted in an antibacterial effect, the mechanism of nitrite action has not been established.

At the levels used, nitrate played no role in retarding putrid spoilage but actively stimulated aerobic spoilage. Our data confirm the findings of several investigators on this point *(15)*. Whether the observed effect of nitrate was due to an ability to overcome nitrite inhibition or involved an actual stimulation of spore outgrowth is not apparent from the data. However, whatever the mechanism, the net result of adding nitrate was an increase in product spoilage due to growth of organisms of the genus *Bacillus*.

Presence of brine, in concentrations up to 5%, does not guarantee stability. This would be predicted by the work of Tanner and Evans *(18)* and others *(6, 15, 16, 21)*. As Halvorson points out, "once a food is heavily contaminated it is no longer possible to check the bacteria by reasonable increases in the salt content" *(9)*.

The phenomenon of sub-lethal injury by mild thermal treatment is an important component of the stability system. Stimulation of spore germination by mild heat shock has long been standard practice in commercial fermentations *(13)*. However, processings of little more severity in a cured meat environment, effectively inhibit the germination and outgrowth of those organisms surviving the treatment. Injured spores, subcultured in a good nutrient medium, grow readily once they are removed from the product. The exact level of heat treatment required to prevent bacterial outgrowth in the cured meat environment has not been established in this work. As has been pointed out previously, pasteurization of product in the temperature range between 155–165° F. is not sufficient to impart shelf stability, whereas retorting procedures which impose barely measurable lethality values change the spores or their environment so that proliferation does not occur within the finished product.

We have presented data which we feel help explain the excellent commercial and public health record of canned cured comminuted meat products. A combination of 78 p.p.m. sodium nitrite, 3.5% brine and a very mild cook results in sufficient injury to the contaminating flora to prevent subsequent growth in the product. Use of sodium nitrate appears to be of questionable value.

The system breaks down when large concentrations of putrefactive anaerobic sports are introduced. Addition of artificially large inocula apparently creates a variable of its own which could be the primary basis for the failure of the bacteriologist to explain the shelf stability and excellent public health history of commercially canned cured meat products.

SUMMARY

Factors responsible for the shelf stability of canned comminuted cured meats were shown to be the combined effect of nitrite, salt, thermal injury and low indigenous spore load.

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Determination of Relative Value of Apples for Applesauce and Evaluation of Experimental Processing Apple Grades

(Manuscript received April 18, 1958)

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Apple processors have purchased apples for processing either on the basis of U. S. grades for apples for processing, or on their own grades, paying different prices for different grades and sizes and for different varieties. The amounts of the grade and size differentials have been a source of misunderstanding between processors and apple producers. Processors also have paid less for a given grade and size of apples that have been run over a grader ("table sorts") than for tree run fruit.

In the spring of 1956, the Virginia Apple Industry Advisory Committee of the Virginia State Horticultural Society, composed of both processor and grower members, requested the Virginia Agricultural Experiment Station to develop a method of calculating price differentials for apples of different qualities and sizes that would reflect the relative value of the fruit to the processors. They also requested an evaluation of the effect on grower returns for apples of different quality that a proposed new set of closer tolerance grades for apples for processing would have in comparison with present U. S. grades. The food technology section of the Horticulture Department already had work under way, in which time requirements in peeling and trimming apples of different grades and sizes and measuring the recovery of different apple fractions were being studied *(2, 3)*. These data were analyzed to determine their usefulness in solving the problem. Although some significant general relationships bearing on the problem were obtained, it was apparent that for determining price differentials applicable to the commercial processing industry some refinements of the experimental methods were desirable. Therefore, in the fall of 1956, the present study was initiated.

EXPERIMENTAL DATA

Data obtained at 4 applesauce processing plants in Virginia and Pennsylvania were included in this study. Experimental

lots of primarily York Imperial variety apples were procured from growers ordinarily supplying apples to each plant. These apples were first mechanically sized into 3 size classes and each size class divided into 2 groups. One group in a size class was graded by Federal-State fresh fruit inspectors according to present U. S. standards with the individual apples being inspected and placed in either culls or U. S. No. 1 or U. S. No. 2 grades, depending upon the per cent waste that would be incurred in cutting out defects in the apple that would not be removed in normal peeling and coring operations. The other group of apples in that size was graded according to the experimental grades A, B, or C. A sufficient volume of apples was prepared in each grade-size class to allow 45 to 60 minutes operation of the portion of the commercial plant placed at the disposal of the research group.

Each lot was carefully weighed before being processed. The apple count was obtained from the semi-automatic peelers. Research workers measured and recorded the time required for trimming each lot and the recovery of: (1) peels and cores; (2) total trim waste; and (3) peeled, cored, and trimmed apples. A sample of trim waste from each grade-size class was sorted to determine the approximate proportion of the total trim waste resulting from defect removal and from removal of peel fragments.

Fifteen experimental lots, 5 grades in each of 3 size classes, were run through each plant in this manner. Two lots were not used because some data were not obtained. Because the hand trimming operation was the limiting factor in the volume of apples that could be put through the production line, other operations occurring both prior to and after the trimming operation were ignored in this study.

ANALYTICAL METHODS

Because of the high cost of preparing the apples in the experimental lots and running them through the plants, replications of samples sufficient to allow significant internal analysis of relationshisp within a plant were not possible. Instead, a statistical method of co-variance analysis, known as differential contrast *(1)* has been used. This method allowed pooling of observations from all plants in determining, by least squares regression, relationships between all the continuous variables, while accounting for variability among plants caused by discrete and unmeasured variables.

Discrete, classifying variables may be included in a regression analysis by assigning a value of unity to a class in which a particular observation occurs and a value of zero to all other classes for that observation. When all classes are included, the coefficients of regression for these classes are not independent; and differential contrast, rather than direct effect, is estimated. One class is given a value of zero and becomes the base class. The regression coefficients for the other classes are then interpreted as "+" or "−" differentials from the base class. The coefficients are estimated by the method of least squares as in the usual regression procedure; however, the intercept will include the value of the base class. A "dummy variate" was used in correcting for the mean.

The mathematical model for all of the regression equations used in this study is of the nature:

$$Y_{ij} = a' + P_i + b_1 \ldots + b_n$$

Where: Y_{ij} equals the trimming time, or other estimated value, per 100 pounds of fresh fruit for the $_j$th observation in the $_i$th plant. P_i is the discrete classifying variable, and $b_1 \ldots b_n$ are continuous variables.

In this method of analysis, the assumption is made that the independent variables will have the same relationship to the dependent variables regardless of the plant in which the observations occur. This assumption does not seem illogical with the relationships involved in this study.

RESULTS AND DISCUSSION

Derivation of price differentials for quality and size. The relative value of apples of different quality and size to applesauce processors is dependent upon: (1) yield of prepared product from a given volume of fresh fruit, (2) value of recovered waste products that can be used in producing other products, and (3) cost of processing and selling the applesauce.

The first factor and the amount of waste products can be obtained directly from the results of this study. The third factor can be derived from information obtained from this study, provided a company knows: (1) relationships that exist between labor costs for peeling and trimming and total company operational costs other than for raw products, and (2) relationship between variable and fixed company operational costs. The usual records kept in apple processing plants will give a quite accurate record as to these relationships. In this paper assumed relationships will be used in lieu of representative plant data.

Yield of apple fractions. Yield of peeled, cored, and trimmed apples should equal the weight of fresh apples minus the weight of peels and cores and trim waste. However, in preparing apples, some spatter occurs that cannot be recovered and errors in weighing are inevitable. Under plant operation conditions, unaccounted-for waste may run as high as 5% of the fresh fruit weight.

In estimating the yield of peeled, cored, and trimmed apples, both peels and cores and trim waste have to be estimated.

Peels and Cores. In the experimental lots, peel and core waste was found to be affected by: (1) plant equipment and plant policy regarding thickness of peel and size of core, (2) size of apples ,and (3) quality of apples as measured by trim waste.

The estimating equation for this relationship was as follows:

$$\hat{Y} = 19.30 + P_i + .0262X_1 + .3088X_2$$

where:

$\hat{Y}$ = Per cent peels and cores
P_i = Plant
X_1 = Number of apples per 100 pounds of fresh fruit
X_2 = Per cent total trim waste

This equation explains 90% of the variability of peels and cores found in the experimental lots. The coefficients and standard errors from this analysis are shown in Table 1.[8]

In estimating peels and cores for this problem the values of 278, 418, and 526 are substituted for X_1. These were the average number of apples per 100 pounds in the 3 size classifications in the experimental lots. The actual trim waste in the apples would be preferable to use as a subsitution for X_2. However, although the actual trim waste is known for the experimental lots *(1)*, it would not be known for apples being purchased by processors. The inspection certifi-

[8] See Appendix A, Table 1, for matrix used in analysis.

TABLE 1

Coefficients and standard errors in estimating per cent peels and cores

Item	Constant	Estimate	Standard error
Intercept	a'	19.30**	1.04
Plant B	P_B	−2.41**	.73
Plant C	P_C	−9.94**	.65
Plant D	P_D	−6.60**	.69
Apples per 100 pounds	b_1	+0.0262**	.0022
Per cent trim	b_2	+0.3088*	.1363

* Significant at 5% level, 51 degrees of freedom.
** Significant at 1% level, 51 degrees of freedom.

cates show only that the trim waste is below a certain level. Therefore, the maximum trim wastes allowed in the grades are used to substitute for X_2. Maximum trim waste allowable in the two U. S. grades and the experimental grades are:

U. S. No. 1	5%
U. S. No. 2	25%
Grade A	3⅛%
Grade B	6¼%
Grade C	12½%

The above substitutions in the equation resulted in estimated peels and cores for the different grade-size classes, for the average of the 4 plants, as shown in Table 2. Peel and core values in Table 2, plus the allowable trim waste in the grades above resulted in total recoverable waste in the different grade-size classes for the average of the 4 plants, as shown in Table 3.

TABLE 2

Peels and cores per 100 pounds of fresh apples (Assumed maximum waste for grade)

Size	Per cent peels and cores				
	Grade				
	1	2	A	B	C
2¾" and up	23.4	29.6	22.8	23.8	25.7
2½"–2¾"	27.1	33.2	26.5	27.4	29.4
2¼"–2½"	29.9	36.1	29.3	30.3	32.2

Peeled, cored, and trimmed apples. The yield of peeled, cored, and trimmed apples was affected by plant differences, per cent peel and core waste, and per cent trim waste. The estimating equation was:

$$\hat{Y} = 99.74 + P_i - 1.0769X_1 - 1.1396X_2$$

where:

$\hat{Y}$ = per cent yield of peeled, cored and trimmed apples
P_i = Plant
X_1 = Per cent peels and cores
X_2 = Per cent total trim

This equation accounted for 85% of the variability in yield existing among the experimental lots. Coefficients and standard errors from the analysis are shown in Table 4.[b]

[b] See Appendix A, Table 2, for the matrix used in the analysis.

TABLE 3

Peels, cores, and trim, per 100 pounds of fresh apples (Assumed maximum waste for grade)

Size	Per cent peels, cores, and trim				
	Grade				
	1	2	A	B	C
2¾" and up	28.4	54.6	25.9	30.0	38.2
2½"–2¾"	32.1	58.2	29.6	33.7	41.9
2¼"–2½"	34.9	61.1	32.4	36.5	44.7

TABLE 4

Coefficients and standard errors in estimating the yield of peeled, cored, and trimmed apples

Item	Constant	Estimation	Standard error
Intercept	a'	99.74**	1.85
Plant B	P_B	2.38**	.64
Plant C	P_C	.17 NS	.84
Plant D	P_D	.51 NS	.71
Peels and cores	b_1	1.0769**	.0608
Per cent total trim	b_2	1.1396**	.1189

** = Significant at the 1% level with 51 degrees of freedom.
NS = Not significant at the 5% level with 51 degrees of freedom.

If the per cent peel and core values in Table 2 are substituted for X_1 and the maximum per cent trim wastes allowed for the grades are substituted for X_2, the yields of peeled, cored, and trimmed apples in the different grade-size classes, for the average of the 4 plants, are shown in Table 5.

TABLE 5

Yield of peeled, cored, and trimmed apples (Assuming maximum waste in grades)

Size	Per cent peeled, cored, and trimmed apples				
	Grade				
	1	2	A	B	C
2¾" and up	69.6	40.1	72.4	67.8	58.5
2½"–2¾"	65.5	36.2	68.4	63.9	54.6
2¼"–2½"	62.6	33.1	65.4	60.8	51.5

Labor requirements in peeling and trimming. The volume of apples that can be processed in a given plant is limited, as stated previously, by the time required to trim the apples. Therefore, all other operations either prior to or following the trimming operation are ignored in this study.

Trimming time. Trimming time was found to be affected by the plant in which the observation occurred, total trim waste, size, and the per cent of total trim resulting from removal of defects. The estimating equation was as follows:

$$\hat{Y} = -4.32 + P_i + 2.1404X_1 + .0378X_2 + .0815X_3$$

where:

$\hat{Y}$ = Trimming time (minutes) per 100 pounds of fresh fruit
P_i = Plant
X_1 = Per cent total trim
X_2 = Apples per 100 pounds of fresh fruit
X_3 = Per cent of total trim due to defects

This estimating equation explained 92% of the variability in trimming time among the experimental lots. Coefficients and standard errors from the analysis are shown in Table 6.[c]

TABLE 6

Coefficients and standard errors in estimating trimming time per 100 pounds

Item	Constant	Estimation	Standard error
Intercept	a'	−4.32*	2.20
Plant B	P_B	7.91**	1.70
Plant C	P_C	8.04**	1.43
Plant D	P_D	1.02 NS	.95
Total trim	b_1	2.1404**	.2750
Apples per 100 pounds	b_2	.0378**	.0034
Defect trim (Per cent)	b_3	.0815**	.0309

NS = Not significant at 5% level, 51 degrees of freedom.
* = Significant at 5% level, 51 degrees of freedom.
** = Significant at 1% level, 51 degrees of freedom.

If the maximum trim waste allowed in the grade is substituted for X_1 the average number of apples per 100 pounds in the different size classes for X_2, and the per cent of total trim that was defect trim for X_3, the trimming time in the different grade-size classes, for the average of the 4 plants, are as shown in Table 7. The per cent of total trim that was defect trim for the different grade classes in the experimental lots was:

U. S. No. 1	39%
U. S. No. 2	57%
Grade A	26%
Grade B	48%
Grade C	53%

TABLE 7

Minutes to trim 100 pounds of apples in the following size and grade classes

(Assuming maximum waste for grade)

Size	Minutes per 100 pounds fresh apples				
	Grade				
	1	2	A	B	C
2¾" and up	24.32	68.60	19.25	27.73	41.52
2½"–2¾"	29.61	73.89	24.54	33.02	46.81
2¼"–2½"	33.69	77.97	28.62	37.10	50.89

Derivation of price differentials for grades and sizes. Values in Tables 3, 5, and 7 in the preceding section can be used in estimating the relative value of the different grades and sizes of apples to applesauce processors. Several assumptions must be made for illustrative purposes. In practice, actual plant data would be used in place of the assumptions.

The assumptions made in this illustration of the method to be followed are:

(1) An applesauce processing plant having 30 4-cup peeling machines, using 4 trimmers and one peeler operator per machine.

(2) Labor rates are at the minimum wage of $1.00 per hour.

(3) Labor for peeling and trimming equals 10% of total company costs exclusive of apple cost when apples of U. S. No. 1, size 2¾ inches and up are used.

(4) Costs exclusive of apples that vary with output of sauce equal 65% of total company costs.

(5) Processors are paying $3.50 per hundredweight for apples of U. S. No. 1 grade, 2¾ inches and up in size.

Plant capacity. In this plant in an 8-hour day there are 57,600 man minutes of trimming time available:

30 machines × 4 trimmers per machine × 8 hours per day × 60 minutes per hour = 57,600 man minutes

If the trimming times in Table 7 are accepted as a basis of calculating the apples that could be trimmed in an 8-hour day in the plant, the quantities in the different grade-size classes for an average of the 4 plants would be as shown in Table 8.

Yield of peeled, cored, and trimmed apples. Applying the yield values of Table 5 to Table 8 quantities of fresh fruit results in yields of prepared product in the different grade-size classes for the average of the four plants as shown in Table 9.

TABLE 8

Apples that could be trimmed in the model plant in an 8-hour day

Size	Pounds				
	Grade				
	1	2	A	B	C
2¾" and up	236,842	83,965	299,221	207,717	138,728
2½"–2¾"	194,529	77,954	234,719	174,440	123,051
2¼"–2½"	170,971	73,875	201,257	155,256	113,185

TABLE 9

Prepared product yield in an 8-hour day

Size	Pounds				
	Grade				
	1	2	A	B	C
2¾" and up	164,842	33,670	216,636	140,832	81,156
2½"–2¾"	127,611	28,219	160,548	111,467	67,180
2¼"–2½"	107,028	24,453	131,622	94,396	58,290

Yield of recoverable waste. If the recoverable waste values in Table 3 are applied to the Table 8 values, the average recoverable waste in an 8-hour day, for the 4 plants, in the different grade-size classes is as shown in Table 10. If this waste is assumed to be worth 75 cents per hundred pounds in production of other products, it would have a value for the average of the 4 plants in the different grade-size classes as shown in Table 11.

Costs of processing and selling. In our model plant, using U. S. No. 1, 2¾" and over apples, peeling and trimming labor costs are $1200 per day. Therefore, under our assumption, total costs other than for

[c] See Appendix A, Table 3, for the matrix used in the analysis.

TABLE 10

Pounds recovered trim, core, and trim waste per 8-hour day

Size	Pounds				
	Grade				
	1	2	A	B	C
2¾" and up	67,263	46,175	77,498	62,315	52,994
2½"–2¾"	62,444	45,672	69,477	58,786	51,558
2¼"–2½"	59,669	45,423	65,207	56,668	50,594

TABLE 11

Value of recovered waste in 8-hour day, waste valued at 75 cents per cwt.

Size	Dollars				
	Grade				
	1	2	A	B	C
2¾" and up	504.47	346.31	581.24	567.36	397.46
2½"–2¾"	468.33	342.54	521.08	440.90	386.68
2¼"–2½"	447.52	340.67	489.85	425.01	379.46

apples would be $12,000 per day in the plant. However, approximately $504 would be obtained from waste products in an 8-hour day; thus resulting in net costs other than for apples of approximately $11,496. If processors are paying $3.50 per 100 pounds of U. S. No. 1 apples, 2¾" and up, the apple cost would amount to $8,239 for the 236,842 pounds of apples used in the plant; or total costs of producing 164,842 pounds of prepared fruit, equivalent to 7,493 cases of size 303 applesauce,[d] would be approximately $19,745 or $2.64 per case. Variable costs, that increase or decrease directly with output of applesauce would amount to $1.04 per case:

65% × $12,000 = $7,800 ÷ 7,493 = $1.04 per case.

Fixed costs would amount to $0.49 per case:

35% × $12,000 = $4,200 − $504 ÷ 7,493 cases = $0.49 per case.

Apple cost would amount to $1.11 per case:

236,842 pounds × 3.5 cents per pound = $8,293 ÷ 7,493 = $1.11 per case.

Applesauce produced from any other quality or size of apples would be worth no more or less to the processor than applesauce produced from U. S. No. 1, size 2¾" and up apples; therefore he would not be willing to spend any more than $2.64 to produce it. In the case of apples of U. S. No. 1 grade, size 2½" to 2¾" in diameter, the plant can produce 127,611 pounds of peeled, cored, and trimmed apples (Table 5), equivalent to 5800.5 cases of applesauce. At $2.64 per case, the processor could spend a total of $15,313 in producing this quantity of apples and be as well off as he would be in producing 5800.5 cases of applesauce from the 2¾" and up size apples:

5800.5 cases × $2.64 per case = $15,313.

Variable costs would be $1.04 per case as in the 2¾ inch and up size group, or a total of $6,033.

5800.5 cases × $1.04 per case = $6,033.

[d] Assuming 22 pounds of prepared apples are used in making a case of 24 No. 303 cans of applesauce.

Fixed costs would be calculated by subtracting the value of recoverable waste from the $4,200 costs incident to each day's running of the plant, or $3,732:

$4,200 fixed cost − $468 value of recoverable waste = $3,732 net fixed cost.

Net costs, other than for apples, in producing 5800.5 cases of applesauce from 2½" to 2¾" size apples of U. S. No. 1 grade would be $9,765:

$6,033 variable costs + $3,732 fixed costs = $9,765.

Subtracting $9,765 from the total costs the processor would be willing to pay for 5800.5 cases of applesauce would leave $5,548 available to pay for 194,529 pounds of apples required to produce the applesauce, or a price of $2.85 per 100 pounds.

A similar procedure was carried out in obtaining the relative price for each of the other grade-size classes of apples. Resulting prices are shown in Table 12.

TABLE 12

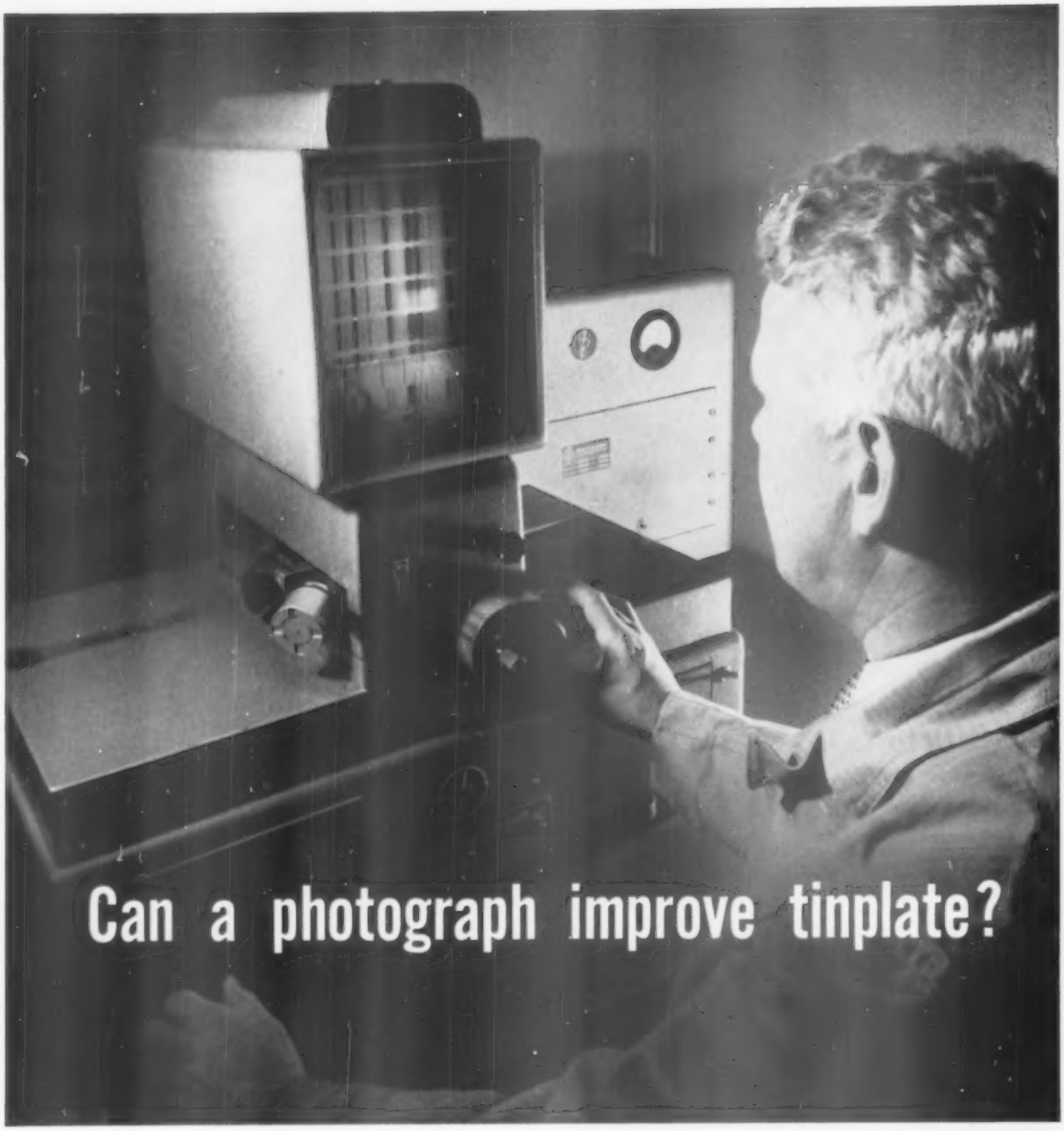
Price per cwt. that could be paid for apples in the different grade-size classes and have same cost of prepared fruit

Size	Dollars				
	Grade				
	1	2	A	B	C
2¾" and up	3.50	0	4.06	3.13	1.51
2½"–2¾"	2.85	0	3.40	2.49	.88
2¼"–2½"	2.36	0	2.91	1.98	.37

A similar procedure would be followed in determining the prices for the different grade-size classes under different assumed prices for U. S. No. 1 size 2¾" fruit, with the new assumed value being substituted for the $3.50 price used in this illustration. With cheaper fruit the company operational costs other than for applesauce would become a more important portion of the total cost of the applesauce, causing size and grade differentials to become relatively greater than they are under the conditions shown above. With higher priced apples the company costs other than for apples becomes a smaller proportion of the total costs, and the price differentials for grade and size would become relatively less.

Evaluation of Present vs. Experimental Grades

Variability in trimming time and yield. Present U. S. grades for apples for processing allow quite large ranges in waste caused by removing defects left after a normal peel and core are removed. In the U. S. No. 1 grade this range is 5% (0% − 5%); in the U. S. No. 2 grade the range is 20% (5% − 25%). The range in the U. S. No. 1 grade is sufficient to cause a variation in trimming time of as much as 10.7 minutes per 100 pounds of fresh apples and a variation in yield of as much as 7.36%. The range in the U. S. No. 2 grade is 4 times as great as in the U. S. No. 1 grade and would have an effect on variation in trimming time and yield 4 times as great as the effect in the U. S. No. 1 grade.



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Processors have found from experience that the trim waste in tree run fruit tends to run much more below the maximum tolerance for the grade than does the trim waste in table sort or drop apple lots. Therefore, they are unwilling to buy table sorts on a strictly grade basis. They will buy them on grade but apply a differential price to compensate for the higher trim probably present in the table sort lots.

Experimental grades narrow the range of trim waste within a given grade, thus reducing the possible variation in trimming time and yield that can occur in a given grade class. The reduction in trim waste allowance in the top grade from 5% to 3⅛% reduces the possible variation in trim time due to effect of trim waste from 10.7 minutes to 6.7 minutes per 100 pounds of fresh fruit. The possible variation in yield is reduced from 7.36 to 4.6%. In the second experimental grade, having a tolerance of 6.25%, the possible variation in trimming time and yield is the same as for the first grade; for the third grade, having a maximum tolerance of 12.5% trim waste the possible variation is two times as great as for the first and second experimental grades. It was hoped by producers that this reduction in possible effects on trimming-time and yield brought about by a narrowing of the possible variation in waste within the grades would cause processors to accept table sorts on a strictly grade basis. This might be possible if all apples were processed immediately following grading. However, in many cases considerable delay occurs between the time the apples are graded and the time they are processed. It is the processor's belief that table sort and drop apples have a higher rate of deterioration during this period than tree run apples have. If this is true some differential should still exist between the two classes of fruit, but the differential should be reduced. This question of differential rates of deterioration should be investigated.

Any reduction in the differential for table sorts would have a beneficial effect on the apple industry by encouraging the removal of low colored apples, being packed for fresh market fruit, thus improving the appearance of the fresh fruit pack.

Effect of Experimental Grades vs. Present Grades on Grower Returns

Another objective of the experimental grades was to more nearly compensate growers of apples on the basis of the value of the apples to the processor. In order to test the effect of the grades on grower returns for apples of different qualities, 38 loads of apples coming in to the processors (approximately 200 bushels per load) were first presized and then graded by Federal-State fresh fruit inspectors into grades U. S. No. 1, U. S. No. 2, and culls and then regraded into grades A, B, and C, and culls.

Sixteen tree run loads having 75% or more of the apples by weight falling in U. S. No. 1, size 2¾" and up were taken as representative of better quality apples. Fourteen other tree run loads having less than 75% of the apples in grade U. S. No. 1, size 2¾" and up represented poorer quality fruit. Eight loads of drop apples represented poor quality fruit.

The apples in these lots were distributed in the different grades and sizes as shown in Tables 13 and 14.

TABLE 13

Percent distribution of apples in the present grade and size classification

Grade and size	Lot I	Lot II	Lot III
	Per cent	*Per cent*	*Per cent*
U. S. No. 1			
2¾" and up	82.6	58.3	40.0
2½"–2¾"	8.9	20.7	14.0
2¼"–2½"	2.9	6.3	9.0
Total U. S. No. 1	94.4	85.3	72.0
U. S. No. 2			
2¾" and up	3.3	8.2	15.8
2½"–2¾"	.4	2.9	4.4
2¼"–2½"	.1	.9	2.8
Total U. S. No. 2	3.8	12.0	23.0
Culls	1.8	2.7	5.0
Total all grades	100.0	100.0	100.0

TABLE 14

Percent distribution of apples in the proposed grade and size classifications

Grade and size	Lot I	Lot II	Lot III
	Per cent	*Per cent*	*Per cent*
Grade A			
2¾" and up	40.9	20.1	2.0
2½"–2¾"	4.6	6.9	1.0
2¼"–2½"	1.5	2.1	.0
Total Grade A	47.0	29.1	3.0
Grade B			
2¾" and up	40.7	40.4	47.2
2½"–2¾"	4.4	13.0	13.0
2¼"–2½"	1.4	4.5	9.0
Total Grade B	46.5	57.9	69.2
Grade C			
2¾" and up	3.8	5.6	11.6
2½"–2¾"	.4	1.9	3.2
2¼"–2½"	.1	.6	2.0
Total Grade C	4.3	8.1	16.8
Culls	2.2	4.9	11.0
Total all grades	100.0	100.0	100.0

Prices quoted by a processor in 1955 were as shown in Table 15, columns 2 and 3. These prices are compared with the prices determined in this study, shown in column 4. Although the calculated price differentials for size was much less than the dealer differential, the apples of U. S. No. 2 quality were of no value under the calculated pricing system while they were paid for under the dealer pricing system.

With lots I and II, graded on the basis of the present grades, U. S. No. 1 and U. S. No. 2, the weighted average price for the lots was essentially the same whether the dealer prices or the calculated prices were applied as shown in Table 16, columns 2 and 3. The lot III calculated weighted price was considerably higher than the dealer quoted price because the dealer did not buy drop apples on the same price schedule as he bought tree run fruit. When the calculated prices were applied to the distribution of apples resulting from the proposed new grades (Table 16,

TABLE 15

Dealer prices versus calculated prices based on the dealer quoted price for U. S. No. 1 fruit, 2¾" and up, present grades

Grade and size

Grade	Quoted		Calculated
	Tree run	Drops and table sorts	
U. S. No. 1			
2⅝" and up	$3.50	$2.75	$3.50
2½"–2⅝"	2.50	1.90	2.85
2¼"–2½"	1.50	1.25	2.36
U. S. No. 2			
2¼" and up	1.00	.75	0[1]
Culls	.75	.75	0[1]

[1] Apples in the U. S. No. 2 grades were not worth the cost of processing.

TABLE 16

Comparison of weighted average prices for three different lots of applese under present and proposed grades using quoted prices and calculated prices

Lots	Present grades		Proposed grades Calculated
	Dealer	Calculated	
Lot I	$3.21	$3.21	$3.33
Lot II	2.79	2.78	2.89
Lot III	1.94	2.33	2.31

column 4), lot I weighted average price was raised 12 cents per hundred pounds. The weighted average price of lot 2 was raised 11 cents and in lot III it was lowered 2 cents. The directional changes in weighted average price, when apples were graded on the basis of the proposed grades, were in a direction that would encourage production of higher quality apples.

SUMMARY AND CONCLUSIONS

This study was designed to develop a method of dedetermining price differentials for processing apples of different qualities and sizes which would accurately reflect their relative values to the applesauce processors. Also it was to be used in evaluating the effect that experimental grades for apples for processing would have on grower returns from apples of different qualities.

Apple value to applesauce processors is dependent upon the yields of prepared product for applesauce from a given volume of apples, values of recoverable waste products that can be used in making other products, and costs of processing and selling the applesauce exclusive of fresh apple cost.

Yield of prepared product was found to be affected by the per cent peels and cores and per cent trim removed from the apples in their preparation. Only slight variations in yield occurred between plants except that which was explained by these factors. Peel and core yields were affected by apple size and by per cent trim. Considerable variation in per cent peel and core waste occurred between plants because of differences in plant policy in regard to thickness of peel, size of core, and differences in equipment and emphasis on defect removal. Because of the fact that Federal-State fresh fruit inspectors do not certify the per cent trim waste in apples in the different grades, the maximum trim waste allowable in the different grades is assumed for each grade.

Trimming time was affected by per cent trim, size of apples, and per cent of the total trim waste resulting from removal of defects. Considerable variation occurred between plants in trimming time that was not accounted for by these factors, caused by presence or absence of incentive or penalty systems and adequate supervision and training in the plants. Trimming time was the limiting factor in the volume of apples that could be run through a plant in a day.

The relationships developed in this study, combined with data either available in the processing plant records or which could easily be developed by a processing plant, can be used to derive price differentials for apples of different quality and size which will be in relation to the relative value of the apples to the processors.

The proposed grades, which narrow the range of trim waste allowed in a given grade will tend to reward growers in proportion to the value of their apples to the processor. The proposed grades will also allow a reduction in the differential now assessed against table sorts. This would tend to encourage better packs of fresh fruit for the industry as a better outlet would be available for table sorts.

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2. Lopez, Anthony, Wood, Charles B., Johnson, Joseph M. Trimming time and yield factors in processing of applesauce. *Food Technol.*, 12, 57 (1958).

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Appendix A

TABLE 1

Matrix for least squares regression analysis of the effect of size (X_4) and per cent trim (X_5) on peels and cores (Y) by plants. X_0 is "dummy" variate including the base plant used to correct for the mean, X_1, X_2, and X_3 are additional plants

	X_0	X_1	X_2	X_3	X_4	X_5	Y
X_0	58	14	14	15	23626	287.87	1556.3
X_1		14	0	0	5791	86.87	415.2
X_2			14	0	5436	63.27	293.2
X_3				15	6392	86.31	384.9
X_4					10242283	119185.82	651355.0
X_5						1655.6985	7786.493
Y							43225.95

TABLE 2

Matrix for least squares regression analysis of per cent peels and cores (X_4) and per cent total (X_5) on yield of peeled, cored, and trimmed apples (Y) by plants. X_0 is "dummy" variate including the base plant used to correct for X_1, X_2, X_3 are additional plants

	X_0	X_1	X_2	X_3	X_4	X_5	Y
X_0	58	14	14	15	1556.3	287.87	3824.2
X_1		14	0	0	415.2	86.87	883.5
X_2			14	0	293.2	63.27	1010.9
X_3				15	384.9	86.31	990.9
X_4					43225.95	7786.493	101035.07
X_5						1655.6985	18701.331
Y							254194.48

TABLE 3

Matrix for least squares regression analysis of per cent trim (X_4), size (X_5), and per cent defect trim (X_6) on trimming time (Y) by plants. X_0 is the "dummy" variate including the base plant used to correct for the mean, X_1, X_2, X_3 are additional plants

	X_0	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_0	58	14	14	15	287.81	27326.00	2601.00	1708.49
X_1		14	0	0	86.87	5791.00	390.00	486.72
X_2			14	0	63.27	5436.00	369.00	422.88
X_3				15	86.31	6392.00	1017.00	459.53
X_4					1655.6985	119190.94	13727.20	9204.7156
X_5						10242280.00	1044250.00	721007.45
X_6							148159.00	76749.43
Y								50326.5186

Maintaining Freshness of Berries Using Selected Packaging Materials and Antifungal Agents[a,b]

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(Manuscript received May 11, 1958)

FRESH STRAWBERRIES and raspberries have very short storage lives after harvest. By comparison, the post-harvest keeping time of cranberries is quite long. Deterioration of berries in the market results from dehydration, discoloration, and over-ripe, mushy, damaged, moldy, or spoiled fruit.

Prepackaging of fresh produce has been introduced to stimulate merchandizing, the sales appeal of the package and the more attractive appearance of the product being the primary factors. Improvement of keeping quality has been considered as a secondary objective. The present study reports experiments conducted to determine if packaging materials or antifungal agents might be used to maintain freshness of strawberries, raspberries and cranberries held in a refrigerated display case.

According to the producers[c] of the several antifungal agents tested in this study, each has demonstrated effective prophylactic action against various fungal infections. It is not known if any or all of the antibiotic preparations that were tried will receive final approval for use as a spray, dip, or wash for fruits. Nevertheless, the present investigators wanted to determine the possibility of prolonging the extremely short shelf-life presently experienced by fresh strawberries and raspberries and to defer to the drug firms manufacturing the chemicals the responsibility of demonstrating their freedom from toxicity and value for use under practical and suitable conditions.

METHODS

Strawberries and raspberries were obtained from the Iowa State College Horticultural Plots. The following varieties or selections were used in the test: strawberries—Superfection, Ogallala, Iowa No. 2 and Armore; raspberries—Black Hawk (black) and Latham (red). Berries were carefully picked and handled and immediately after harvest transported to the Food Processing Laboratory for trials. After examining the berries individually and discarding all that were not sound, the remaining fruit was distributed in pint or quart plastic or wood boxes.

Cranberries were obtained from a local grocery store in 24-pound boxes at the time of truck-delivery to the retailer.

Antifungal agents[d] used were: nystatin, myprozine, rimocidin, ascosin and candidin. In addition, the antibiotic chlortetracycline was used alone or in combination with one of the antifungal agents listed above. Also, in field trials, the fungicide captan was used. Stock solutions of the antifungal agents in dimethyl formamide (reagent grade) were prepared at a concentration of one milligram/milliliter. Ascosin and candidin were obtained as crude lyophilized extracts which yielded preparations that were olive brown or yellow brown in color. The powdered candidin was not as completely soluble in dimethyl formamide as were the other antifungal agents. Appropriate amounts of each stock solution were added to sterile distilled water to produce antifungal solutions containing 0, 5, 10, 20, 50, and 100 μg./ml.; captan was used at a level of 0.2%.

For the dipping tests, berries were transferred to sterile cheese cloth; the 4 corners of the cloth were gently held together while the berries were rapidly dipped in and out of the appropriate solution. After 10 successive immersions and drainings, the berries were air dried with the aid of an electrically heated forced air drier before placing them in berry boxes. After the containers had been filled they were wrapped in cellulose acetate,[e] 300 PHD- and LSAD-cellophanes, polystyrene Q-641.4, polyethylene .0015", Mylar 50 gauge or Cryovac. Unwrapped berries served as controls in the comparisons of wrapping materials.

Cranberries were handled in a manner similar to that used for strawberries and raspberries except that they were packaged directly in cellulose acetate, LSAD, kraft paper bags, Visten, Q-641, Mylar, Saran or polyethylene rather than in berry boxes.

For the field trials, the berries were sprayed with a 3-gallon garden sprayer using 1-gallon amounts of antifungal agents or fungicide. The berries were allowed to air-dry for a period of about 2 hours before being picked. Unsprayed berries were used as controls. In addition, a second series of controls consisted of berries sprayed with water only.

Twenty grams of the berries were weighed into sterile petri dishes on pan balances. The berries were then covered until the samples were transferred to sterile half pint fruit jars containing 200 ml. of sterile water. A sterile Osterizer blade assembly was then screwed to the top of the jar and the sample blended for 2 minutes. Aliquots of the blended sample were transferred to sterile petri dishes and pour plates were prepared using acidified malt agar (pH 4.5) and nutrient agar

[a] Presented at the 18th Annual Meeting of the Institute of Food Technologists, Chicago, Ill., May 28, 1958.

[b] Journal Paper No. J-3421 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project No. 1054; Agricultural Adjustment Center, cooperating.

[c] The physiological effects of these antifungal agents, if used in foods, have not been clearly established. Practical use of these agents in foods is not permitted at the present time.

[d] Sources of the antifungal agents were as follows: nystatin (mycostatin)—E. R. Squibb and Sons, Brunswick, N. J.; myprozine—Lederle Labs. Div., American Cyanamid Co., Pearl River, N. Y.; rimocidin—Chas. Pfizer & Co., Brooklyn, N. Y.; ascosin—Commercial Solvents Corp., Terre Haute, Ind.; candidin—Merck & Co., Rahway, N. J.

[e] Sources and characteristics of the packaging films were as follows: cellulose acetate 100 gauge, type 48; PHD cellophane 300; LSAD cellophane 300; Mylar 50 gauge, clear, uncoated—E. I. Du Pont de Nemours & Co., Wilmington, Del. Polystyrene Q-641.4, 1 mil (MVT rate 5 g./100 sq. in./24 hrs.) and Saran 50 gauge—Dow Chemical Co., Midland, Mich. Polyethylene (Visqueen) 1.5 mil dbl. 6" flat width and Visten 2 mil 6" flat—Visking Co., Chicago, Ill. Cryovac 60 and 75 gauge—Cryovac Co., Cedar Rapids, Ia.

(pH 7.0). These were incubated at 30° C. for 48 hours. At that time the plates were counted with the aid of a Quebec Colony Counter.

Strawberries and raspberries were sampled after 0, 1, 2, 3, 4, 5, 7, and 9 (or 10) days[1] of storage. Cranberries were sampled at 0, 2, 4, 7, 10, 14, 30, 45, and 60 days of storage. All berries were stored in a refrigerated self-service display case. The display case was maintained at a temperature of 5° C ± 3° except for the cycle break. Two cyclings per day with 90 minute breaks were used for most of the trials. During the break interval the temperature of the berries did not rise above 10° C. at any time.

Changes in numbers of molds and yeasts and of total counts were determined at each of the test intervals. Data on weight losses were obtained from changes in gross weight of the container and berries. The plastic containers weighed 9 g. ± 0.5 g. and the packaging film weighed 4 g. ± 0.8 g. Since these weights were constant and were only a small part of the total weight (250-350 g.) the packaging materials were not reweighed except to determine the amount of free juice that remained.

RESULTS AND DISCUSSION

I. Antifungal Agents

Post harvest dipping. In preliminary tests, strawberries of the varieties Superfection, Ogallala, and Iowa No. 2 were dipped in solutions containing myprozine in concentrations of 5, 10, 20 or 50 μg./ml. with the following results: the keeping quality of berries dipped in 10 μg./ml. was superior to that of berries treated with 5 μg./ml. or water dipped controls (See Figures 1 and 2). Microbial counts of berries dipped in 10 μg./ml. were reduced when compared with the controls. While the number of microorganisms recovered from strawberries dipped in antifungal solution was considerably less than that of

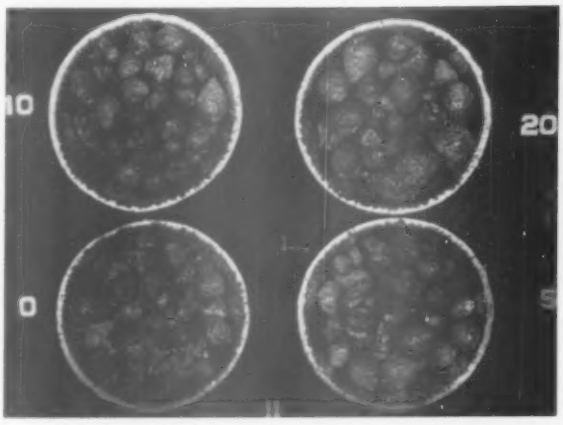

Figure 1. Effect of myprozine on the keeping quality of strawberries (Iowa No. 2) 9 days after treatment. Berries dipped in 10 or in 20 μg./ml. myprozine were free of visible spoilage while those dipped in solutions containing 0 or 5 μg./ml. showed extensive mold development.

berries dipped in water, there was little difference after 7 or 9 days of storage between the total number recovered from berries treated with 10 or 20 μg./ml. (Figure 3). At a concentration of 50 μg./ml., myprozine was found to be quite an effective inhibitive agent.

The antifungal agents, candidin, ascosin, nystatin, myprozine, and rimocidin were compared at levels of 10 μg./ml. and 20 μg./ml. (Figure 4). Berries used for these tests were rinsed and air dried before they were immersed in water (control) or in the solutions containing antifungal agents. Candidin, ascosin (not shown since it produced effects similar to those for candidin), and nystatin at a level of 10 μg./ml. appeared to stimulate the development of yeasts and

[1] In the series of tests used to compare the microflora of strawberries dipped in candidin, nystatin, myprozine, and rimocidin, samples were made at 0, 2, 6, and 12 days.

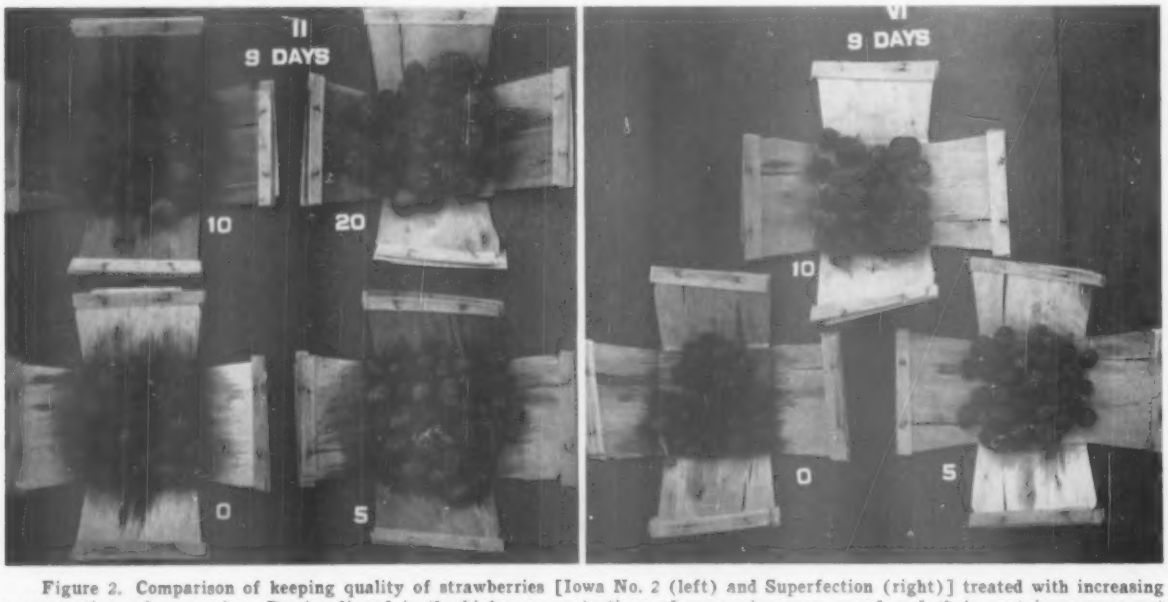

Figure 2. Comparison of keeping quality of strawberries [Iowa No. 2 (left) and Superfection (right)] treated with increasing concentrations of myprozine. Berries dipped in the higher concentrations of myprozine were sound and their containers were not soaked with seepage of juice from spoiled fruit.

molds while rimocidin and myprozine were inhibitory. During the early part of the storage period rimocidin appeared to be a more effective fungistat than was myprozine. When the concentration of antifungal in solution was increased to 20 μg./ml., myprozine and rimocidin were equally inhibitory while growth of microorganisms was enhanced in the presence of candidin or ascosin. Another of the antifungals—nystatin—at levels of 20 and 50 μg./ml. reduced the microbial load on strawberries but at 10 μg./ml. had an opposite effect. After 12 days storage samples dipped in 10 μg./ml. nystatin had counts of 1,150,000 per gram whereas berries that were dipped in water only had 220,000 organisms.

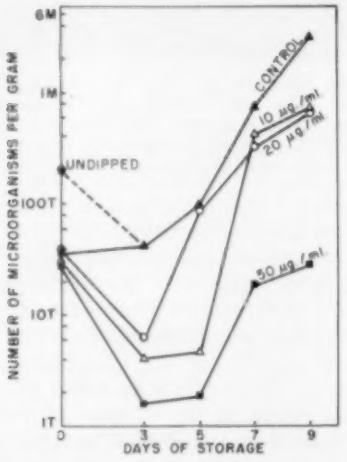

Figure 3. Effect of myprozine on number of microorganisms on strawberries held in a refrigerated display case (5° C. ± 3°).

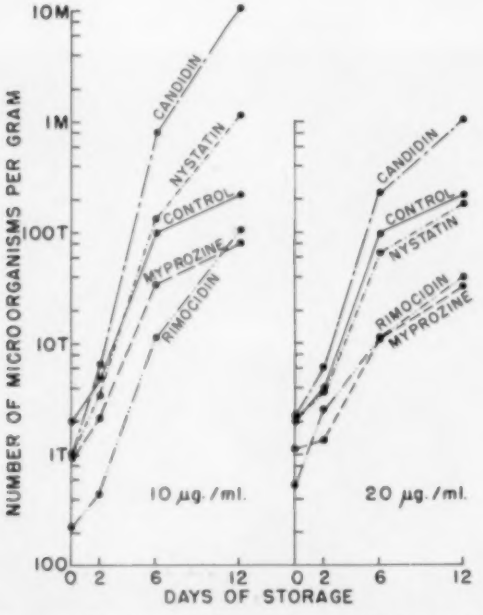

Figure 4. Number of microorganisms developing on strawberries dipped in water or in water solutions containing 10 or 20 μg./ml. of antifungal agent.

It should be mentioned that the condition of use for these antifungal agents may not be the most desirable. For example, it is known that nystatin is not as effective a bacteriostat at 4° C. as it is at 37° C.; yet, the berries were stored at approximately 5° C.

When Black Hawk (black) raspberries were dipped in solutions containing 10, 20, 50 or 100 μg./ml. myprozine, a direct relation was shown between the amount of antifungal agent used and the number of molds and yeasts that developed during storage. All levels of antifungal treatment gave reduced loads when compared with controls.

Use of myprozine at a level of 100 μg./ml. prolonged the expected 6-day storage life to 10 days. Visual appearance of raspberries treated with the antifungal solutions at a level of 100 μg. was much more desirable than when 10 μg. were used. After 10 days of storage very little mold growth was observed with the highest level used; 50 μg./ml. permitted a couple of mold colonies to develop while, with 20 μg., several spots appeared and with 10 μg. more mold areas developed. The controls at this time were covered with mold.

Similar results were obtained for red raspberries (Latham) as for black. As may be seen in Figure 5,

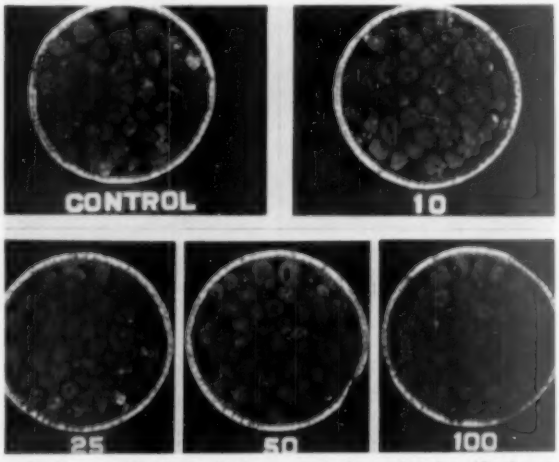

Figure 5. Mold development on red raspberries (Latham) treated with myprozine and stored in a refrigerated display case (5° C. ± 3°) for 10 days.

the higher the concentration of myprozine, the fewer mold colonies developed during storage. Berries used in this test were not of as good quality as were the black raspberries. At time of harvest the weather was unusually hot and dry, and the skins of many of the berries were whitened by scorching or sunburning. This loss of bloom on the fruit surface should not be confused with mold growth. As shown in Figure 5, berries treated with 50 μg./ml., the injury to fruits (a) adjacent to the region of 7 o'clock and (b) just to the right of center is quite distinct from the infection shown in berries (the lower right portion at 3,

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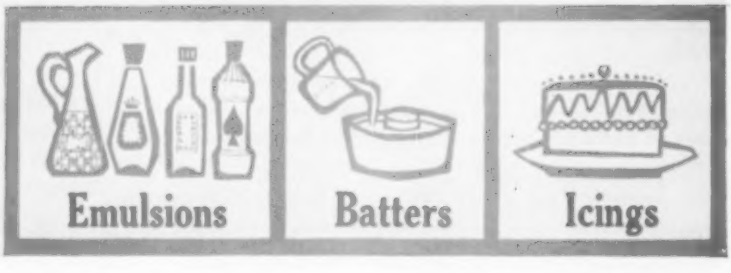

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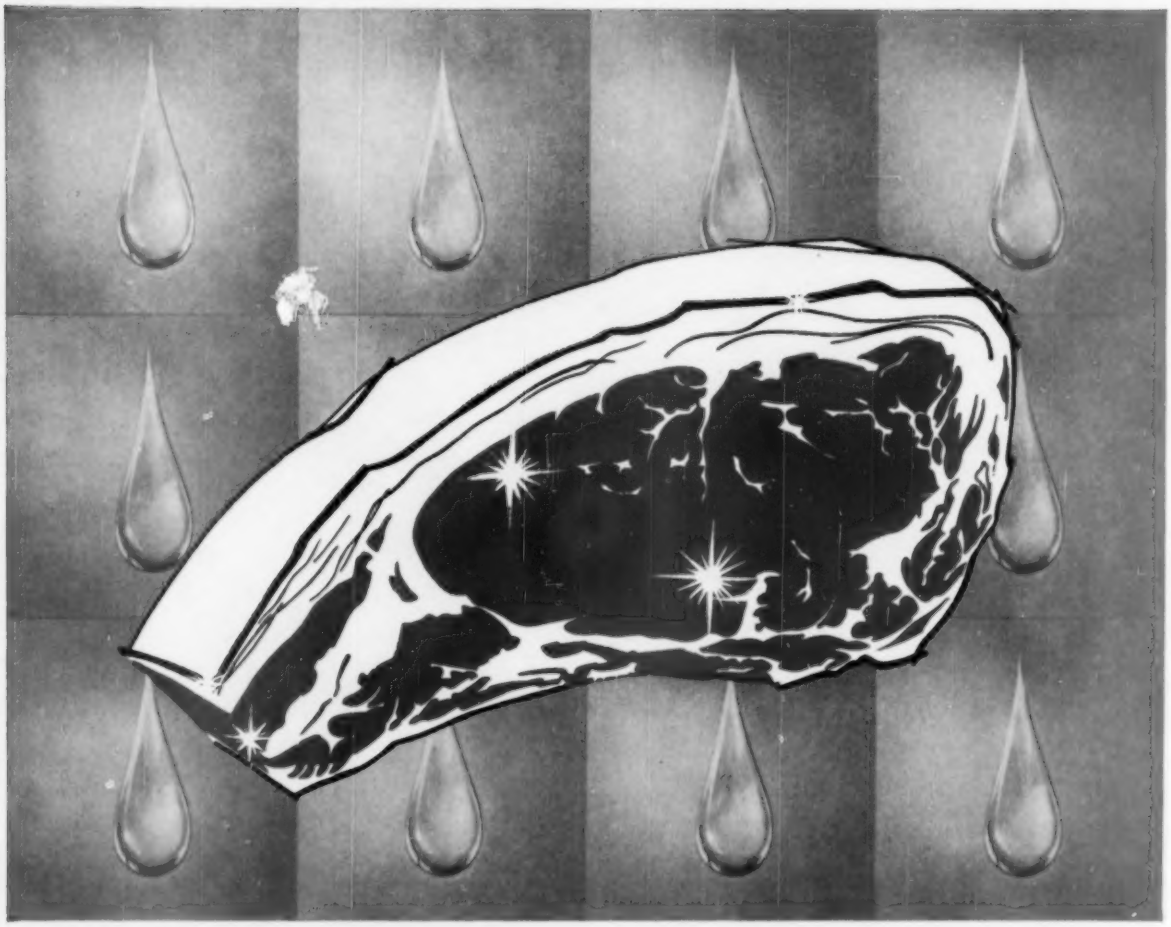

A "liquid dip" for wrapping meat

A more attractive way of packaging frozen meat is now being tested. It's an all-around airtight wrap that seals in fresh red color that's ordinarily lost after freezing. The process is simple: An initial immersion in an ethyl cellulose base hot melt followed by a liquid dip in the insulating coating of which one of the ingredients is glycerine. The glycerine acts as a plasticizer and humectant. It helps keep the package clear and prevent slip.

Another approach is described in a recent Belgian patent. This time a dip of hot 60-80% Glycerine solution heat-seals polyethylene into an airtight film around the meat.

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near 4, and 5 o'clock) that had been immersed in 25 μg./ml. myprozine. Over 50% of control berries and only 2% of berries treated with 100 μg./ml. showed visible evidence of mold growth after storage for 10 days.

At a level of 100 μ./ml., chlortetracycline reduced the total load of organisms on raspberries but, as would be epected, had very little effect on proliferation of yeasts and molds. When chlortetracycline and myprozine were used in combination at 50 μg./ml. of each, results were not as favorable as when a 100 μg./ml. myprozine dip was employed. Insofar as counts of yeasts and molds were concerned, use of myprozine and chlortetracycline in combination was no more inhibitory than was myprozine alone. Further, at a level of 30 μg./ml., it was found that the antifungal was as effective when used alone in reducing total counts at it was when used in combination with the antibiotic.

Figure 6 shows that cranberries dipped in 10 μg./ml. myprozine had a change in mold count from 300

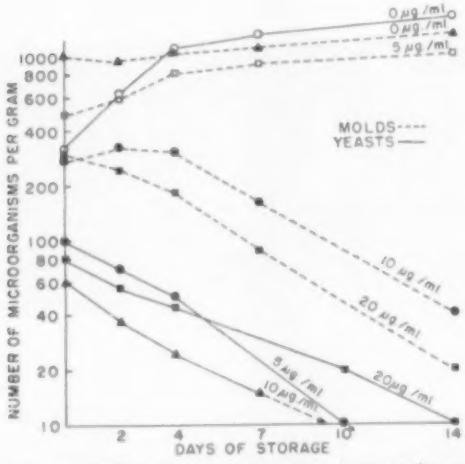

Figure 6. Influence of concentration of myprozine on numbers of molds and yeasts recovered from cranberries.

per gram to 40 per gram after 14 days' storage; after the same storage period those dipped in 20 μg./ml., of the antifungal agent had a count of 20 per gram. Using myprozine at 5 μg./ml., the counts changed from 480 to 1000 per gram while controls had 1000 organisms initially and 1300 at the end of the two week period. Myprozine dips of 10 μg./ml. and 20 μg./ml. were equally effective for both yeasts and molds.

Field spraying. When strawberries (Armore variety) were sprayed in the field shortly before harvest rather than dipped post-harvest in the laboratory, all antifungals had less beneficial effect on keeping quality. Berries sprayed with solutions containing 10 or 20 μg./ml. antifungal agents gave only slightly lower counts at 6 days than did the controls.

When used at a level of 50 μg./ml., rimocidin, myprozine, nystatin and candidin lowered the yeast and mold count but the results were not as conclusive as those obtained when berries were dipped in the laboratory. Berries sprayed with rimocidin or myprozine consistently showed less breakdown or disease than those treated with the other antifungals; candidin and ascosin were the least inhibitory.

The fungicide captan also was sprayed on strawberries at a level of 2 mg./ml. (2000 μg./ml.) but no differences in counts between berries containing the fungicide and the controls were noted. In addition, an unsightly residue or visible film of captan remained on the berries.

It may be seen in Figure 7 that 4 or 5% of the berries sprayed with rimocidin or myprozine deteriorated within 7 days; 9–10% of control berries indicated mushiness or decay by 5 days; also at 9 days, 12 and 16%, respectively, of strawberries treated with rimocidin and myprozine were not sound; 32% of the unsprayed (dry) control- and 39% of the sprayed (wet) control-berries showed signs of deterioration. Tests were terminated after storage for 9 days; in trials extended beyond that time, over-ripening, dehydration and discoloration were the principal causes of deterioration. Fewer unsound berries were found after the 9th day of storage in berries sprayed with nystatin than with water but little improvement was noted in the keeping quality of berries treated with this antifungal.

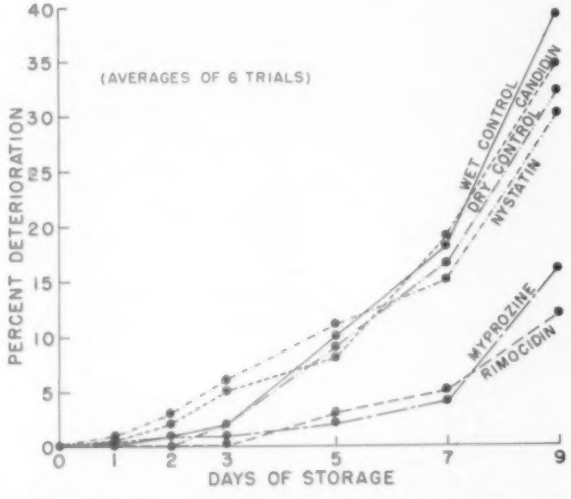

Figure 7. Percent deterioration of strawberries (Armore) receiving preharvest antifungal field sprays at levels of 50 μg./ml.

In field trials, Black Hawk and Latham varieties of raspberries were sprayed with water, captan, myprozine, rimocidin, nystatin and candidin; also an unsprayed control was used for comparative purposes. Again, the fungicide captan failed to reduce yeast and mold counts. As was true with strawberries, the antifungal agents gave only slightly lower counts at 6 days than did the controls. Less spoilage was observed in berries sprayed with rimocidin or myprozine than in those treated with the other two antifungals.

II. Packaging Materials

In trials with several packaging materials it was found that the water vapor transmission rates and gas permeability of cellulose acetate, PHD- and LSAD-cellophanes, polystyrene Q-641, Mylar (50 gauge), and polyethylene .0015" were sufficient to conduct exploratory studies with these films for wrapping strawberries and raspberries. Cellulose acetate was considered the packaging film of greatest promise. For the most part the other films allowed insufficient water vapor transmission and, as a consequence, there was "fogging" of the package in the self-service display case during (or following) cycle breaks. With films such as LSAD-cellophane and polystyrene Q-641, this fog or condensate disappeared within 15–30 minutes after the refrigeration break but with other films, such as Mylar and polyethylene, the condensate was so excessive that droplets of moisture coalesced inside the film and dripped on the fruit or collected underneath. During hot weather this condition was intensified.

After 3 days' storage, the general appearance and color of strawberries and raspberries packaged in cellulose acetate was more desirable than that of unwrapped berries; at that time, the unpackaged fruit had lost part of its original bloom and showed evidence of dehydration. During 7 days of storage there was little difference in the appearance of raspberries packaged in LSAD and Q-641 from those wrapped in cellulose acetate. On the ninth day, however, berries packaged in LSAD-cellophane, Q-641, Mylar and polyethylene had become darker in color and some of the berries had become soft and mushy, and tissue breakdown had produced an unsightly collection of juice within the package. The daily weight losses of berries wrapped in Q-641 and polyethylene was slight. In LSAD weight loss was approximately 0.6–1.1% daily while that of fruit packaged in cellulose acetate indicated a daily loss of 1.5–2.7%.

Figure 8 shows that cranberries packaged in cellulose acetate or in PHD-cellophane had a 14% loss of weight after 60 days' storage in a refrigerated display case held at 5° C. Similarly, berries packaged in LSAD-80 cellophane had a 12% weight loss. These changes in weight represented considerably greater losses of moisture than were found in berries placed in kraft paper bags. It is interesting to note also that unwrapped cranberries showed smaller losses of moisture than those packaged in cellulose acetate or PHD-cellophane or those packaged by the processor in a perforated cellophane bag. Presumably this loss of weight is due to escape of moisture vapor through the film while with unwrapped berries moisture recondensed during the cooling cycle and was not permanently lost to the berries. Moisture losses of approximately 7% for Visten and polystyrene Q-641 and of 4.3 and 4.8% for Mylar and Pliofilm HM-120 contrasted with slightly more than an 8% loss in kraft paper bags. Under the same conditions berries wrapped in polyethylene, Cryovac or Saran had losses of approximately 1%.

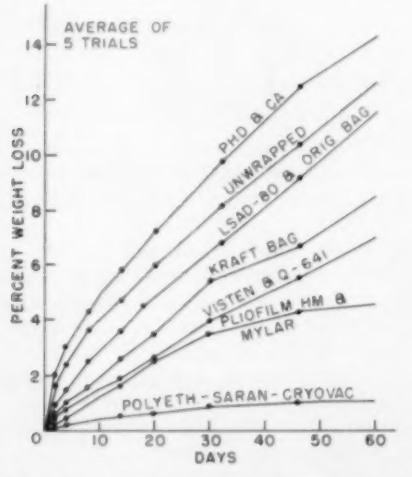

Figure 8. Percent weight losses of cranberries bagged in various packaging materials and stored at 5° C.

Figure 9 shows that berries packaged in Mylar or in polyethylene appeared satisfactory after storage

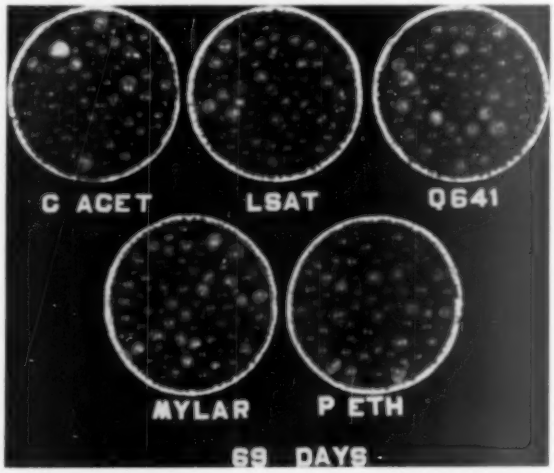

Figure 9. Appearance of cranberries packaged in various films after 69 days storage in a refrigerated display case (5° C. ± 3°). Berries stored in Mylar (50 ga.) and polyethylene (.0015") were plump and had good color.

for 69 days while those wrapped in cellulose acetate, LSAD-80 cellophane and polystyrene Q-641 had several shriveled, discolored berries. In all tests wherein berries were stored for 30 days or longer the color and firmness was most satisfactory if they were packaged in Mylar, Saran or polyethylene rather than in the more permeable films. However, these films did not permit sufficient water vapor transmission and so the berries appeared moist and there was some condensation of water in the package.

In trials wherein some of the berries were placed in wooden boxes while others were stored in plastic containers, spoilage almost always proceeded more rapidly in the wood container. When wooden berry boxes were reused, contamination was even more pro-

nounced; the plastic containers allowed better circulation and drainage of any juice that had collected from unsound berries. It is believed that wooden boxes were impregnated with molds and, during transportation and handling, the organisms were transferred to the fruit forming a nidus for infection.

Since most berries are picked before they are completely ripe, they may improve in quality during the early days of storage. During this time they continue to lose moisture by dehydration and respiration and to take up oxygen and give off carbon dioxide. If the fruit is packaged immediately after harvest, shrinkage of the product due to moisture loss may be reduced. However, if the wrapping film does not permit adequate transmission of water vapor and is insufficiently permeable to gases, the humidity within the package approaches 100% r.h. accompanied by the depletion of oxygen and accumulation of carbon dioxide. With the development and maintenance of high humidity within the package, the berries lose firmness, take on a watery appearance and conditions become favorable for mold development. In addition to encouraging mold growth Ulrich (1955) found that excessive accumulation of water vapor disturbed ripening and caused inferior flavor.

With reduction of the level of free oxygen, conditions become unsuitable for decay but well suited for fermentation by yeasts. Even with films as permeable as LSAD and Q-641, strawberries and raspberries develop wine-like odor after 4 or 5 days of storage.

Apparently a film with a permeability intermediate to that of cellulose acetate and LSAD-cellophane is indicated. Study of the respiration rate of strawberries and raspberries would be of value in determining the optimum type of film to utilize so that the rates of water vapor transmission and permeability to gases of the film coincide with the physiological processes of the berries.

SUMMARY

Strawberries and black and red raspberries dipped in solutions containing myprozine had lower microbial counts after storage than did controls. Trials with other antifungals showed that candidin, ascosin, and nystatin at 10 μg./ml. were stimulatory to mold and yeast development. At 20 μg./ml., growth of microorganisms was enhanced with candidin or ascosin but not with nystatin; myprozine and rimocidin were inhibitory at both concentrations.

With increasing amounts of myprozine, fewer mold or yeast colonies developed on strawberries, raspberries, or cranberries. Also, with increased concentration of antifungal there was a larger proportion of sound berries.

Strawberries and raspberries sprayed with 50 μg./ml. of rimocidin or myprozine in the field were consistently more sound than were those treated with other antifungals. Candidin and ascosin were the least inhibitory. Antifungal sprays applied immediately prior to harvest gave poorer fungus control than did laboratory dipping tests. Field applications of captan at 2 mg./ml. (2000 μg./ml.) failed to reduce mold counts.

The use of plastic containers generally resulted in less spoilage of strawberries and raspberries than when the fruit was stored in wooden berry boxes especially if the wood boxes were used previously.

Cellulose acetate was considered the most promising film for wrapping strawberries and raspberries. The other films did not allow sufficient water vapor transmission. Cranberries packaged in cellulose acetate and PHD cellophane had greater weight loss throughout a 60-day storage period than unwrapped cranberries. In all tests wherein cranberries were stored for 30 days or longer, color and firmness were most satisfactory if the fruit was packaged in Mylar, Saran or polyethylene rather than in the more permeable films.

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Notes and Letters

The Military Subsistence Supply Agency*

THE MISSION of the Military Subsistence Supply Agency is to procure, inspect, and distribute food to all of the U. S. Armed Services both here and overseas. This includes not only prepared foods, which are mainly in the category of non-perishable subsistence, but also fresh and perishable foods. Our job includes all functions involved in transferring food from field or factory to the mess kitchens and galleys of the ultimate consumers: the soldier, sailor, airman, and marine. Not only do we enter the market to *buy* items within these categories, we also ship and store them at warehouses and depots and, from these central locations, redistribute them to continental military installations and to ports for consumption at oversea bases.

THE MARKET CENTER SYSTEM

The initial job in 1941 was to buy fresh fruits and vegetables for the many military camps which sprang up throughout the country. The immediate success of that original enterprise—founded on standard everyday commercial practice and procedure—warranted its rapid expansion. Before the end of the war there were 36 market centers, and they had extended their shopping list to include all perishable foods. By then, too, and under informal cross-service agreements—which were to continue after the war—the customers included the Navy and the Marine Corps. The Air Force, as you remember, was a part of the Army and received food supplies from its parent service.

After 1945, there was no thought of discontinuing the war-proved food-buying organization. It had been efficient, effective, and economical. Its size, of course, was reduced. With only minor acceleration, this normal-sized organization was able to cope with the food buying job during the Korean War.

In 1953, after the Korean episode, The Quartermaster General integrated the assignment for purchasing non-perishable foods—formerly a task of his depot procurement agencies—into the market center system, and a single-service purchasing agency for all subsistence was born.

In 1956, as a result of the Hoover Commission studies and others, the single manager concept of procurement came into operation; namely, a single agency to serve all the Armed Forces in common areas of commodities and services. Duplications and possible waste were thus eliminated.

THE MILITARY SUBSISTENCE SUPPLY AGENCY

Only a short time ago, the Quartermaster Market Center System became the Military Subsistence Supply Agency, one of several new single manager or central procurement agencies established by the Secretary of Defense to effect unified supply services for all the military departments. The Headquarters of the system has always been Chicago. Here a central office directs and coordinates the activities of its subsidiary market centers, field buying offices, subsistence inspection offices, and storage depots.

Ten market centers are located in assigned geographical regions of supply. Three are inland, at Kansas City, Fort Worth, and Chicago. The remaining centers are at or near the ocean ports from which they not only supply installations within their areas but also export subsistence to U. S. bases overseas.

Purchasing activities at the market centers are supplemented at permanent field buying offices. For the most part these offices—affiliated with the market center of their area—are located in areas of heavy food production or concentration.

Also, as an addition to our geographic set-up, we activate temporary field buying offices during seasons of heavy food production or harvest. From these offices, buyers go to the fields and orchards to make on-the-spot purchases directly from the growers. Literally, the buyers follow the crops, moving from one area to another as one harvest season ends and another begins.

For the most part, each market center purchases subsistence for installations within its area or to fill oversea requisitions through its port. They also buy items abundant in their own food-growing areas for shipment to installations in other market center sectors. For example, market centers at Chicago and Kansas City do most of the meat buying; New Orleans buys our shrimp; Seattle is the principal buyer of salmon and apples; and Los Angeles and Oakland supply the major portion of lettuce, melons, and citrus.

There is no over-all pattern governing the kinds of food we buy. Purchases are made to fill the ordered needs of the stations we serve. Procurements are based on requisitions received from them about 40 days in advance of delivery. Individual requirements for the Army and Air Force are based on a master menu plan published monthly by The Quartermaster General after determination by a joint committee of these services. Component selection considers the nutritional adequacy, acceptability, and universality of items and, as well, recognizes the economy and season of the national food supply situation.

* Presented at the 18th Annual Meeting of the Institute of Food Technologists, May 26, 1958, Chicago, Illinois.

The basic principle, however, that underlies our buying operations is to buy the best suitable quality of subsistence for the Services and to obtain such supplies at the lowest cost to the Government. To achieve this, we procure the largest usable quantities and, wherever possible, buy direct from producers. We are not permitted, nor do we desire, to speculate on food prices or to make purchases to bolster or support the market.

PURCHASING PROCEDURES

In operation, our purchasing procedures compare in scope and method with those of the national grocery chains. We obtain fresh produce from the field or from centers of primary supply; where large quantities can be used, we ship them direct to our consuming installations. Smaller stations, which cannot use food by the carload, receive supplies from the larger installations or from central refrigerated warehouses where carlot purchases can be stored. At these distribution points, the carload lots are broken down into mixed truck loads for delivery to the small stations as required.

Canned items ordinarily are bought during seasons of heaviest production and stored in depots for delivery to the military installations when needed. These annual seasonal purchases not only are convenient for us, they likewise please the packer because they enable him to meet more efficiently those requirements for military items, can sizes in particular, not present in commercial operations.

Our buying continues to be done by competitive negotiation. This procedure has been approved for subsistence by Congress. In operation, the process is the same as that of business and, of course, is one that is geared to the highly fluid economy of the food market. It in no way eliminates competition. In fact, it continues to provide us with growing lists of competitors for Government business. Based as it is on commercial practice, the system is one that is understood and used everyday by our suppliers themselves.

Bids for carlots of subsistence may be received simultaneously by all market centers. Low regional bids are forwarded to Headquarters for coordination. Evaluation, however, is made by the central or control market center and awards subsequently are made to the lowest qualified bidder by that market center or the one to which he submitted his bid. A modern system of communications permits these operations to be completed within a few hours.

Shipments for use in any particular sector may come from any other sector in the country. On occasion—certainly not very often—meats have been delivered to the Chicago area by west coast packers. Normally, however, timely supplies come from within areas of consumption because all supplies are subject to premiums which must be added to bids for shipping charges.

To show the scope of our operation—our sales program is approximately $60 million per month or $720 million per year. Perishables, that is fresh and frozen items, run to about $38 million per month. Over 50% of such food is purchased and delivered directly to using continental installations or shipside for export. The remainder is purchased generally in carlots, broken down at a distribution point, and shipped in mixed trucklots to consuming installations.

Our nonperishable sales are about $22 million per month. Over 50% is purchased for direct delivery. The remainder is delivered to depots for subsequent shipment to consuming installations. Brand name items for oversea commissaries are shipped directly to shipside. The major portions of our requirements for flour, sugar, evaporated milk and coffee are shipped directly to installations, thus saving a handling charge as well as delivering a fresher product.

To support this sales program of $60 million per month we maintain at present an operating inventory of about $68 million; $18 million in perishables and $50 million in nonperishables.

INSPECTION

Quartermaster food inspectors are aided in this phase of our general assignment by inspection personnel from the Veterinary Corps and from the U. S. Department of Agriculture. To inspect the many diverse types of foods that are procured, MSSA employs the services on a full or part-time basis of approximately 800 inspectors from 5 divisions of the USDA, 400 Veterinary Corps inspectors, 45 MSSA inspectors, personnel of the Subsistence Testing Laboratory, and the Federal Food and Drug Administration. These elements assure that the quality of merchandise delivered to the Military is equal to that specified in the procurement document.

Inspection of food for the Armed Services begins in the field and remains in effect all the way to the point of delivery. Our inspection system is comparatively rigid. This is necessary because the items we buy must meet the quality standards you people help to establish. This not only insures the integrity of the product, but also gives assurance that bids will be awarded on a fair and equitable basis to all sincere and qualified competitors. Marginal and non-qualified producers are discouraged when quality standards are strictly observed.

MSSA is currently entering into a program of contractor inspection wherein the vendor is made responsible for tests and examinations necessary to determine that supplies meet the quality standards specified. By utilizing the present quality control facilities that producers have and use to manufacture their products, economies in inspection are anticipated. Among the items presently being tested by the contractors themselves are evaporated milk, dried milk, ice-cream mix, eggs whole stabilized, chewing gum, corn starch, macaroni, spaghetti and noodles. This list will be expanded in the future as quickly as implementing procedures for other items are devised.

EFFICIENCY INCREASED, WASTE ELIMINATED

As we now see them, the advantages in the across-the-board procurement assignment we now possess are

showing up in better control of military subsistence stocks and inventories. Information is now centrally available concerning on-hand quantities possessed by all the Services. As a result, we know better when to go out for additional procurements and, equally important, how to plan the efficient distribution of stocks we already own.

This has enabled us to reduce our inventories. In turn, this means savings in the form of interest on funds that are invested in on-hand stocks. It also means that we are able to eliminate waste resulting from duplication and overlapping of goods and services between the military departments, as the Hoover Commission charged.

BETTER FOOD FOR THE MILITARY AT LOWER COST

This all adds up to our belief that we are ever more efficiently achieving our basic assignment: to provide better food to the military services with lower costs to the taxpayers.

Our experience under single-manager procurement shows quite clearly that the military services can and do get along very well together. General Twining recently testified that the Army, Navy, Air Force and Marine Corps were, and I quote, "ready to fight as a team today or any day." I can assure you that they are certainly eating as one.

Permit me to conclude on a note that reflects the opinion of the ultimate member of that team—the individual service man. The general inspection reports that we receive are notable by the dearth of individual complaints against military food. By providing the technological developments in food and food processing, you have played an important part in achieving this situation.

It is fitting, indeed, to recognize and to compliment your efforts on this score. You have helped to raise the standards of military subsistence from the level of the campfire to its present position. And I can best describe that by asserting that today the military group is without doubt the best fed group in the national population.

CHARLES A. SHAUNESEY, JR.
Colonel, U. S. Army Quartermaster Corps, and Chief, Requirements and Distribution Division, Hq., Military Subsistence Supply Agency, Chicago, Ill.

May 15, 1958.

A Sample Rotator for the Hunter Color and Color-Difference Meter

PRECISE MEASUREMENT with the Hunter Color and Color-Difference (HCD) Meter[a] of the small color changes which occur in frozen food products due to various storage conditions depends upon minimizing two types of error. One source of error is the color variation between portions of the heterogeneous sample. Reducing this error by the usual practice of obtaining the average of readings on several portions of the sample can be a time-consuming procedure. The other source of error stems from the technique of measurement. Minimizing this error requires that sample presentation be exactly reproducible to insure maintenance of a constant sample-meter geometric relationship.

The rotator attachment for the HCD meter described herein provides a means for quickly minimizing the errors and makes it possible to determine accurately the small color changes of heterogeneous samples with a considerable saving of time. A single reading on a rotating sample corresponds to the average of several readings on different smaller areas of the same surface, and is usually obtained with the container at rest on the instrument. The two values generally agree within the precision of the HCD meter.

The design of the attachment insures a high degree of reproducibility in sample container placement with respect to the aperture of the instrument, providing a running clearance of only $\frac{1}{64}$-inch. This space affects the scale readings less than 1% and does not seriously hamper the direct comparison of the rotator data with

[a] Mention of specific products does not imply endorsement by the Department of Agriculture over others of a similar nature not mentioned.

PROVERB PRATTLE

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those obtained without it. In this respect, the attachment is an improvement over other arrangements which have been described *(1, 2, 3)*.

Figure 1 shows the rotator attachment mounted on the HCD meter with a sample inserted. The front cover is removed to show the arrangement of parts. A conveniently located switch, 1, and the variable transformer, 2, control the voltage at the universal, $\frac{1}{80}$ horsepower motor, 3. The rotational power is applied through the 36 : 1 speed-reducing gears of the motor to the clutch, 4, mounted on the upper end of the shaft, 5. The collar, 6, is locked to the shaft by means of a set screw and rests on the inner race of the lower ball bearing contained within the mounting block, which supports the weight of the shaft and attached parts. The mounting blocks for the upper and lower bearings have provisions for alignment; the collar provides a means for the vertical adjustment of the shaft. The cell holder, 7, fitted to the lower end of the shaft and fastened on it with a set screw, grasps the cell in a groove with 4 fingers. Any one of these fingers can be lifted against spring tension and locked open for easy cell insertion and removal. Three fingers guide and raise the cell as it is pushed over the aperture, and the fourth finger automatically completes the positioning when lowered.

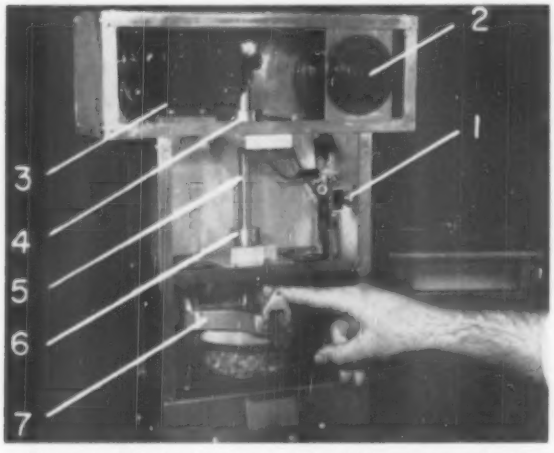

Figure 1. The rotator attachment, which mounts with screws through slots in its frame to the top of the Hunter Color and Color-Difference Meter, was photographed with the front aluminum cover plate removed to show the construction of the frame of ⅛ x ⅛-inch brass angle stock and the arrangement of parts: 1-switch, 2-variable transformer, 3-motor, 4-clutch, 5-shaft mounted in ball bearings, 6-collar, and 7-cell holder.

Details of the clutch, cell holder and cell design are illustrated in Figure 2. Dimensions are in inches. The uppermost part is the coupling on the motor shaft. The lower end of the coupling is cut to fit into the slot in the inner plate of the clutch. This inner plate is held up in contact with the cover plate by means of a compression spring of suitable strength, which fits in the hole bored in the shaft. The brass clutch is packed with a lubricant of suitable viscosity, similar to stopcock grease, so as to provide free hand turning of the cell holder when stopped and only minor slippage while attaining speed. This feature is important for the convenient changing of the sample containers, the safety of the operator, and the protection of the speed-reducer gears and motor.

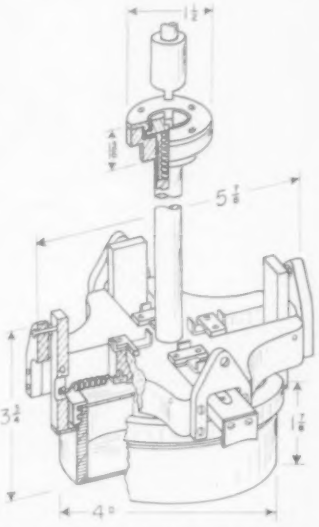

Figure 2. The drawing, with dimensions in inches, illustrates by cut-away sections, design details inside the clutch, hidden parts and the construction of the cell holder and cell.

Construction details of the cell holder are illustrated in the lower part of Figure 2. The main block was machined from a $\frac{3}{4}$-inch sheet of aluminum alloy. The center hole was reamed to fit the $\frac{1}{2}$-inch shaft, and 4 radial slots were cut $\frac{3}{4}$-inch wide, $1\frac{1}{2}$ inches long and 90 degrees apart. Four brass fingers pivot in the slots on horizontal pins. The near finger is shown held in the open position by the sliding lock at the inner end of the slot, while its lower end protrudes outward through the yoke. The cutaway section at left shows another finger held in the closed position against the adjusting screw in the yoke by means of a spring hooked between a screw in the block and a small pin through a hole in the finger. The perpendicular extension at the lower end of each finger fits in the groove cut into the cell body below the cover rim.

The sample containers were made alike for interchangeability; each must have its groove cut at exactly the same distance above the bottom. The body of the cell was machined from polymethyl methacrylate tubing, and a $\frac{1}{16}$-inch sheet of this plastic material forms an insert for the aluminum cover rim. The glass bottom is cut from the same type of $\frac{1}{32}$-inch plates, especially selected for freedom from color and optical flaws, which has proved satisfactory for measurements without rotation. The cutaway section of the sample container in Figure 2 illustrates how the glass bottom is inlet into the lower edge of the $\frac{1}{4}$-inch plastic wall, a type of construction which helps provide a strong cement joint. The outer edge of the plastic wall extends about $\frac{1}{128}$-inch below the glass for added pro-

tection from scratching. The cells have proven capable of withstanding the shocks of normal usage, as well as some of unusual severity.

The averaging effect arises from the inertia of the galvanometer and its linear response to current at small deflections. The speed of rotation required to accomplish this effect depends on the sample color variations and the ability of the instrument to respond to the rapidly changing signal derived from them. The speed of rotation is adjustable up to about 250 r.p.m., a speed being selected to almost eliminate the fluctuations of the Rubicon [a] high sensitivity (0.002 ua/mm) spotlight galvanometer supplied with the HCD meter. Adjustment to the lowest speed permissible is desirable to prevent appearance changes due to the outward movement of liquids and loosely packed samples. Furthermore, a perceptible amount of fluctuation is an aid to the precise alignment of the moving shadow line with the index of the galvanometer scale. The highest speed is necessary when color variations are large such as, for example, were found for a sample of sliced peaches. For this sample, the Rd scale readings on the 4 quadrants, when held stationary, varied from 20.1 to 27.0; the variations for the *a* scale were 9.3 to 14.1 and for the *b* scale 25.2 to 29.6. While the standard deviations from the mean were 2.9, 2.2, and 1.8, respectively, for the Rd, *a* and *b* scales, their readings on the rotating sample differed only 0.1, 0.2, and 0.3 from the means of the corresponding scale readings on the stationary quadrants. Speeds higher than 250 r.p.m. have not been found necessary, and a setting at less than half of the maximum is usually adequate for color measurements on most heterogeneous food products.

The equipment is engineered for rapid, convenient, and safe operation, to withstand extended hard usage with minimum upkeep, to maintain precise adjustments and to provide reliable color data throughout long-term laboratory experiments.

SUMMARY

The design of an improved rotator attachment for the Hunter Color and Color-Difference Meter is described, which facilitates the color measurement of heterogeneous food products. The rotator averages the color variations of a sample surface of several times greater area than that illuminated by the meter and affords a proportionate saving of reading time. The main improvement in design results in such close reproduction of the normal sample position, at rest on the instrument's aperture, that the rotator data agree within one per cent with those usually obtained.

Acknowledgments

The authors express their thanks for valuable suggestions to John Peruzzi and his staff, who built the rotator, and to K. J. Palmer and C. H. Kunsman for encouragement during the development of the sample rotator.

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14 March 1958

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[1] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

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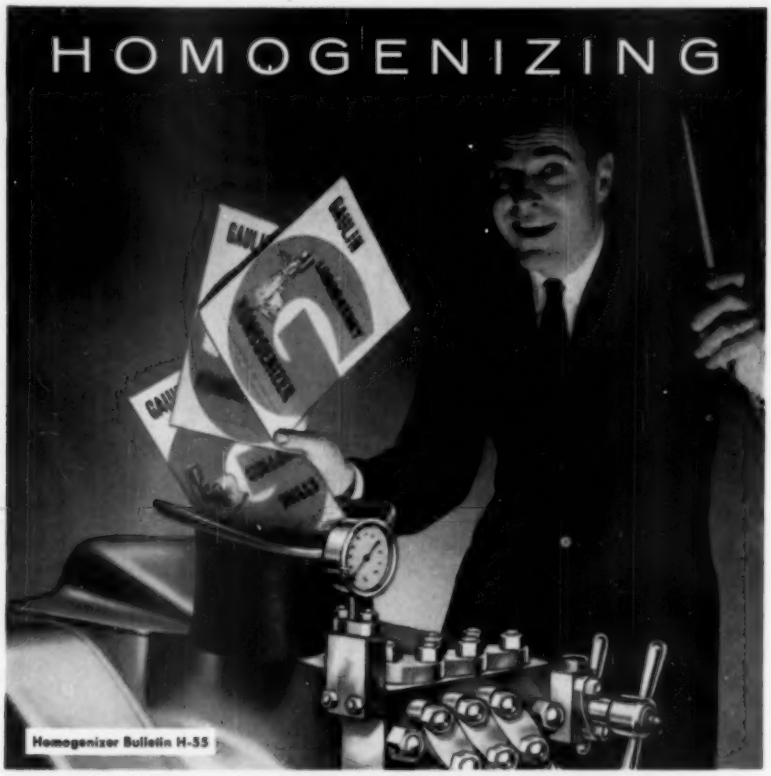

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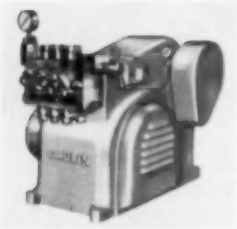

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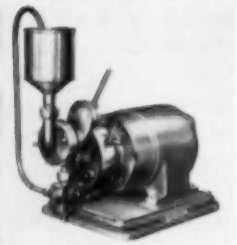

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General

Food and container problems of the Armed Forces, 1958. Research and Development Associates, Food and Container Institute, Inc., 1849 W. Pershing Rd., Chicago 9. 50 pp. pap. apply.

Nutrition Foundation, Inc. Report of the Executive Director, 1957. New York 16. The Foundation, 99 Park Avenue, 1958. 68 p. pap. apply.

Includes summaries of work done and in progress.

Research Tools

Experimental designs in industry. Edited by Victor Chew. John Wiley and Sons, Inc., New York, 1958. $6.00.

A symposium held at North Carolina State College (November 1956) and sponsored by the Mathematics Division, Air Force Office of Scientific Research, Air Research and Development Command.

Technical editing. Edited by B. H. Weil. Reinhold Publishing Corp., New York, 1958. $5.75.

Basic concepts and practices of technical communications.

Information and communication practice in industry. Edited by T. E. R. Singer. Reinhold, New York, 1958. $8.75.

Methods of handling technical information.

Oral communication of technical information. Robert S. Casey. Reinhold, New York, 1958. $4.50.

Tips for technical people on how to tell about their projects effectively.

Bibliographies

List of publications & patents with abstracts, July-December 1957. Albany, Cal., Western Utilization Research & Development Division, U.S.D.A., 1958. 8 p. processed. (WURDD list no. 5.) pap. apply.

A similar list is issued by the other regional laboratories.

Preliminary list of publications, prepared by the Library Branch. Chicago, Ill., Quartermaster Food and Container Institute for the Armed Forces, 1958. 9 p. processed. Apply.

The list includes bibliographical data for certain of the Institute publications most asked about at the Library Branch.

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Electrodialysis using ion-exchange membranes. I. Factors limiting the degree of desalting.

PARTRIDGE, S. M. AND PEERS, A. M. *J. Appl. Chem. 8,* 49–59 (1958).

The behavior of KCl solns. in a continuously operated electrodialysis cell using ion-exchange membranes is described. The cell contained 25 desalting

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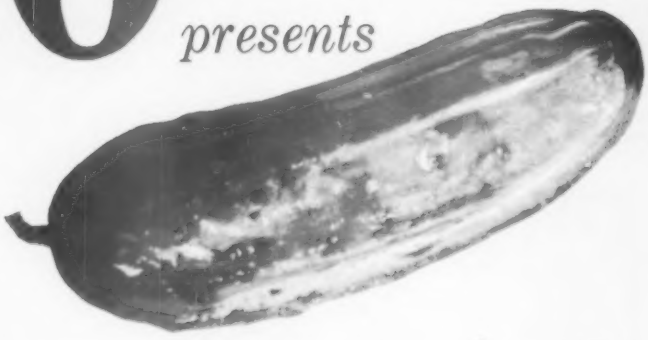

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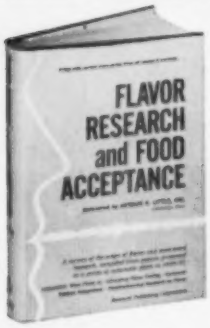

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compartments and 25 concentrating compartments each 1.58 mm. thick. The membranes were supported by perforated separators carrying grooves for the passage of liquid, and turbulent flow was induced by forced recirculation. The dependence of current efficiency on the ion concn. in the desalting compartments was assessed and the effect of a number of design factors was investigated. Theoretical expressions have been derived for the current efficiency of the desalting process.

Precision calorimetric measurement.

PATTISON, J. R. (Plant Eng. and Energy Div., B.I.S.R.A., London, Engl.). *Research in Appl. Ind. 11*, 192–202 (1958).

Much of the tabulated enthalpy data in works of reference was obtained by calorimetric methods which were not refined by the technological advantages at the command of present day investigators. The calorimeter designs capable of the greatest accuracy are the Bunsen ice calorimeter and the adiabatic aneroid calorimeter of which the former is capable of the higher precision. Although there is considerable activity with other forms of calorimeters, the field of the macrocalorimetry of common metals and chemical substances has been virtually ignored. A study of true specific heats by continuous direct detn. would also help to replace the technological data at present available to industry by more reliable figures.

Drying and decomposition of sodium carbonate.

NEWKIRK, A. E. AND ALIFERIS, I. (General Electric Research Lab., Schenectady, N. Y.) *Anal. Chem. 30*, 982–4 (1958).

Thermobalance curves are given for the drying and decompn. of Na_2CO_3 in the temp. range from 25 to 1040° C. using different crucible materials and atms. The reaction of Na_2CO_3 and silica resulted in a wt. loss at temps. as low as 500° C. It is recommended that Na_2CO_3 for anal. use be dried in platinum to prevent errors due to its reaction with silica and silicates.

BIOLOGICAL SCIENCES

Biochemistry

Mechanism of protein turnover studied with cystine-S^{35}, lysine-C^{14} doubly labeled plasma proteins of the dog.

GOLDSWORTHY, P. D. AND VOLWILER, W. (Dept. of Med., Univ. of Washington, Seattle). *J. Biol. Chem. 230*, 817–31 (1958).

The decrease with time of the concn. of S^{35} and of C^{14} in serial samples of plasma albumin, γ-globulin, fibrinogen, and α-globulin was followed for 60 days in dogs. All corresponding exponential components for both lysine-6-C^{14} and cystine-C^{35} were identical in each protein fraction studied. Average apparent half lives were 16 days for albumin, 19 days for α-globulin, 20 days for fibrinogen, and 23 days for γ-globulin. The significance of these findings is discussed. The data appear to support the occurrence of complete protein degradation as a mechanism of protein turnover.

Countercurrent distribution of serum albumin.

HAUSMANN, W. AND CRAIG, L. C. (Labs. of Rockefeller Inst. for Medical Research). *J. Am. Chem. Soc. 80*, 2703–10 (1958).

In the search for systems which might permit fractionation of proteins by countercurrent distribution, a study of the behavior of serum albumin has been made. It was found possible to distribute this protein with no detectable denaturation in a system contg. a small amt. of trichloroacetic acid. While these systems did not provide resolution of the closely related forms of serum albumin, resolution from a number of other protein types was easily accomplished. More interesting from the standpoint of countercurrent distribution was the fact that a band far too narrow was obtained. An explanation of the phenomenon was found. Of further interest is the fact that a molecule as large as 68,000 can be successfully distributed. The use of acetyltryptophan was found helpful in recovery of the protein.

The cross-linking action of formaldehyde on the proteins of the groundnut: a physico-chemical investigation.

KINNEAR, A. M. AND NAISMITH, W. F. *J. Appl. Chem. 8*, 286–90 (1958).

The cross-linking action of formaldehyde on the arachin and conarachin-II fractions of groundnut protein in the pH range 6-11 has been studied by means of the ultracentrifuge. When suitable steric conditions are obtained, cross-linking of conarachin II takes place with the formation of dimers, trimers and tetramers of the parent molecule, the optimum effect being obtained at pH 8. In the case of arachin, evidence for the formation of formaldehyde cross-linkages is found in the effect of the formaldehyde treatment on the dissocn. and denaturation reactions of the protein. The nature of the functional groups responsible for the formation of formaldehyde cross-linkages is discussed.

The thermal condensation of glutamic acid and glycine to linear peptides.

HARADA, K. AND FOX, S. W. *J. Am. Chem. Soc. 80*, 2694–7 (1958).

Although glutamic acid is converted by heat virtually entirely to the inner lactam, it undergoes copolymerization with

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each of many amino acids to yield linear peptides. The effects of conditions of reaction have been studied for the copolymerization of glutamic acid and glycine. The dialyzed products, of average molecular wt. 11,000–20,000, have also been characterized in yield, amino acid compn., N-terminal amino acid compn. and infrared absorption spectra.

The inhibition of ribonuclease by acidic polymers and their use as possible antiviral agents.

HEYMANN, H., GULICK, Z. R., DE BOER, C. J. AND MAYER, R. L. (CIBA Pharm. Products Inc., Summit, N. J.). *Arch. Biochem. Biophys. 73*, 366–83 (1958).

The anti-RNase activity of 66 acidic polymers of largely synthetic origin has been investigated. In the test system used, activities of half-inhibition at concns. of 1 μg./ml. in protein-free media were frequent. The degree of inhibition is decreased markedly by proteins, and to a varying but lesser extent by salts, or increase of pH. Numerous other polymers, as well as nonpolymeric substances, have been similarly tested, with neg. results in almost all instances. Among the acidic polymers, a number of the highly active RNase inhibitors have anti-influenza and antivaccinia activities in eggs. The possible relationship between anti-RNase activity and virus inhibition in embryonated eggs is discussed.

Microbiology

Microbiological process report, analytical microbiology. IV. Gravimetric methods.

GAVIN, J. J. (Food Research Labs., Inc., Long Island City, N. Y.). *Appl. Microbiol. 6*, 80–5 (1958).

Advantages and disadvantages of gravimetric procedures are discussed. Methods are simple, inexpensive, reliable, precise and work with highly colored solns. Some disadvantages are that such methods are time consuming, not adaptable to large numbers of samples, require more incubation space than tubes, and are routinely applied only to a few vitamins for which other methods are not available.

Protein and fat content of some mushrooms grown in submerged culture.

REUSSER, F., SPENCER, J. F. T. AND SALLANS, H. R. (Prairie Regional Lab., Natl. Research Council of Can., Saskatoon). *Appl. Microbiol. 6*, 1–4 (1958).

Ten strains of mushrooms were grown on synthetic media and on media contg. molasses or waste sulfite liquor. High nitrogen concn. favored protein production and reduced nitrogen concn. induced fat formation. High yield of dry matter and protein were obtained on molasses media. Yields in waste sulfite liquor were slightly lower.

Biological value of proteins of unicellular green algae and their effect on liver necrosis. II.

FINK, H. AND HEROLD, E. (Univ. Cologne, Ger.). *Z. Physiol. Chem. 307*, 202–16 (1957); *Chem. Abstr. 52*, 8305 f (1958).

The biol. value of the protein of *Scenedesmus obliquus* is equal to or superior to that of the protein of milk and eggs, when these materials form the protein of the diets of growing albino rats. The diets contained 92% egg white protein or milk protein, in the form of skim-milk powder, or 92% crude algal protein. When diets contg. only protein of young spinach or alfalfa plants were substituted for milk or egg proteins, the algal diets were superior. Dietary liver necrosis was absent in rats fed the algal protein, and was found in rats fed the milk, egg white, or alfalfa diets. The significance of these findings is discussed in terms of usefulness in human nutrition.

Production of microbial enzymes and their applications.

UNDERKOFLER, L. A., BARTON, R. R. AND RENNERT, S. S. (Miles Labs., Inc., Clifton, N. J.). *Appl. Microbiol. 6*, 212–21 (1958).

The processes for industrial production of microbial enzymes by surface and submerged procedures have been reviewed. A table listing current industrial uses of enzymes has been presented and the major uses of the microbial carbohydrases (amylases, invertase, lactase and maltase), the proteases, the pectinases, glucose oxidase and catalase have been described.

The persistence and biological effects of antibiotics in soil.

PRAMER, D. (Rutgers State Univ., New Brunswick, N. J.). *Appl. Microbiol. 6*, 221–3 (1958).

Since antibiotics are a heterogeneous group of compds., varying greatly in their chem. structure and reactivity, and soils are not homogeneous, but differ physically, chemically, and biologically within wide limits, no generalizations regarding the stability and biol. effects of antibiotics in soil are possible at this time. The fate of each antibiotic in any particular soil remains a unique situation that requires investigation. Although our present knowledge indicates that some antibiotics in soil are unstable chemically, and many, if not all, are degraded microbiologically, it appears that several antibiotics persist in some soils for a sufficient time to have a biol. effect.

A 50-gallon pilot fermentor for classroom instruction.

FULD, G. J. AND DUNN, C. G. (Dept. of Food Technol., Massachusetts Inst. of Technol., Cambridge). *App. Microbiol. 6*, 15–23 (1958).

Using Salt Efficiently

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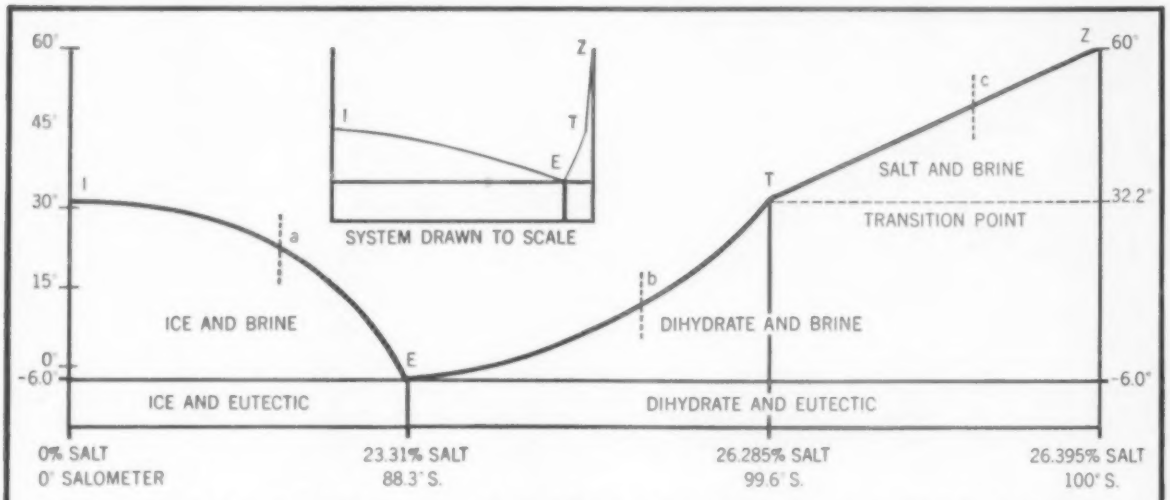
How to Calculate Effects of Freezing Temperatures on Brine

Every plant that refrigerates with brine, or that makes, stores or uses brine in cold, unheated places can benefit from knowing what happens to brine at freezing temperatures. Information on brine freezing characteristics is helpful in determining the best brine strength for particular temperatures . . . in designing facilities for most efficient use of brine at low temperatures . . . and in dealing with other problems of brine usage in the plant. **As a quick reference** on these matters, International Salt Company has prepared this data on brine behavior at low temperatures.

3 ranges of brine concentration. For purposes of this explanation, three different brine-strength ranges must be considered: Range I brine, between 0° S. and 88.3° S.; Range II brine, between 88.3° S. and 99.6° S.; and Range III brine, between 99.6° S. and 100° S. Freezing temperatures produce different effects on each range of brine strength. These effects are explained in the following graph.



RANGE I—less than 88.3° S. Brine at less than 88.3° S. has a lower freezing point than water. When this point is reached ("a" on graph, for instance), pure water separates out as ice, leaving the liquid phase more concentrated with salt. If the temperature drops further, more ice will separate out, leaving the liquid with a still higher salt concentration. At -6° F., there is a mixture of pure ice and brine of 88.3° S. As more heat is removed, this mixture freezes into a solid mass of ice and "eutectic"—the latter a composition of 23.31% salt and 76.69% water.

RANGE II—88.3° S. to 99.6° S. When a brine between 88.3° S. and 99.6° S. drops below 32° F., it stays liquid until a certain temperature is reached ("b" on graph, for example). At this point, crystals of sodium chloride dihydrate begin to form. The dihydrate is composed of 61.863% salt, only 38.137% water. As the temperature drops further, more dihydrate separates out . . . and the remaining brine gradually *weakens* until it becomes 88.3° S. at -6° F. At this point, the mixture of brine and dihydrate crystals freezes solid into eutectic and dihydrate.

RANGE III—99.6° S. to 100° S. When brine is between 99.6° S. and 100° S., pure-salt crystals start to separate out at some temperature between 60° F. and 32.2° F. ("c" on graph). This is because the cooler the brine, the less salt it can hold. When this mixture of salt and brine drops below 32.2° F., dihydrate forms, as it does in Range II brines. With dihydrate removing more salt than water, the weakened brine can then dissolve the pure salt. This goes on until -6° F., when once again the mixture freezes into a solid mass of dihydrate and eutectic.

To sum up: at -6° F., salt brine of any composition whatever freezes solid. Between this temperature and 32° F., pure ice separates out of brine *weaker* than 88.3° S., and dihydrate crystals form in brines *stronger* than 88.3° S. In brines originally over 99.6° S., pure salt separates out at some temperature above 32.2° F., then is dissolved as dihydrate is formed in temperatures below 32.2° F.

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Nutrition

Lysine requirements of the young pig.

Nutrition Revs. 16, 15–16 (1958).

Lysine requirements of the pig suckling age appears to be larger than that of the weanling pig when calcd. on the basis of % of total ration. The optimal level of lysine was found to be 0.52% of the dietary protein.

The utilization of D-leucine for growth by the rat.

Rechcigl, M., Loosli, J. K. and Williams, H. H. (Dept. of Biochem., Cornell Univ., Ithaca, N. Y.). *J. Biol. Chem. 231*, 829–37 (1958).

Experiments have been conducted for the purpose of detg. whether the unnatural enantiomorph of leucine can be utilized by rats. The results furnish definite proof that the oral supplementation of leucine-free or deficient, amino acid type diets with D-leucine will support the growth of young rats. This finding has been confirmed by the comparison of L- and DL-leucine fed at different levels. This is believed to be the first demonstration of the utilization of D-leucine for growth of the rat. The difference between the results of these studies and earlier studies to the contrary may be in the compn. of the exptl. diets.

Influence of estrogens on body growth and food intake.

Sullivan, L. W. and Smith, T. C. (Boston Univ. School of Med., Mass.). *Proc. Soc. Exptl. Biol. and Med. 96*, 60–4 (1957).

The effects of estradiol and its benzoate ester on body wt. and food consumption of immature male rats have been studied in expts. using controls which were either eating *ad lib.* or pair-fed to the treated animals. In animals eating *ad lib.*, estrogen treatment for 3 weeks or more resulted in a depression of body wt. accompanied by a voluntary restriction in food intake. Restriction of food intake in the controls to amts. eaten *ad lib.* by the treated animals duplicated the effects of the estrogen on depression of body wt.

Relationship between food intake and osmotic effect of dietary carbohydrate.

Harper, A. E. and Spivey, H. E. (Dept. of Biochem., Univ. of Wisconsin, Madison). *Am. J. Physiol. 193*, 483–7 (1958).

In general the evidence obtained is in accord with the hypothesis that the high osmotic capacity of low mol. wt. dietary carbohydrates limit food intake by increasing the vol. of water drawn into the stomach. This rather than a difference in the efficiency of protein utilization appears to be the major factor responsible for the lower rate of growth of rats on low protein diets in which sucrose or glucose is substituted for dextrin or cornstarch.

Interactions of dietary fiber and protein on food intake and body composition of growing rats.

Meyer, J. H. (Dept. of Animal Husbandry, Univ. of California, Davis). *Am. J. Physiol. 193*, 488–94 (1958).

The addn. of cellulose to the diet increases protein needs as measured by gains in the fat-free body of *ad libitum* and pair-fed growing rats. This was attributed to loss of metabolic fecal nitrogen induced by dietary cellulose addn. It was demonstrated that 30% cellulose addn. to the diet caused a need for about 1.85% addnl. dietary crude casein.

Lessons from serum cholesterol studies in Japan, Hawaii and Los Angeles.

Keys, A., Kimura, N., Kusukawa, A. *et al. Ann. Int. Med. 48*, 83–94 (1958); *J. Am. Med. Assoc. 167*, 256–7 (1958).

Among Japanese, as in the case of most of the world's populations, when the diet is increased in fats, this increase is mainly accounted for by increasing the consumption of the more satd. types of fats, as represented by beef, pork, and dairy products. So far, all investigations on populations subsisting on low-fat diets show a low incidence of atherosclerosis and coronary heart disease and a low average level of cholesterol in the blood in comparison with populations who subsist on high-fat diets.

Hypercholesteremia and atherosclerosis induced in rabbits by purified high fat rations devoid of cholesterol.

Lambert, G. F., Miller, J. P., Olsen, R. T. and Frost, D. V. (Abbott Labs., Chicago, Ill.). *Proc. Soc. Exptl. Biol. and Med. 97*, 544–9 (1958).

Rabbits fed cholesterol-supplemented purified diets contg. 20% of hydrogenated shortening or safflower oil showed lower plasma cholesterol levels on safflower oil diets, but only negligible differences between oils with respect to aortic atheroma production. Similar studies with cholesterol-free diets showed that rabbits on hydrogenated coconut oil are much more prone to hypercholesteremia than rabbits on safflower oil diets. In these latter studies aortic atheromatous lesions developed in all rabbits in 16 weeks on 20% of satd. fat as contrasted to negligible lesion production on 20% safflower oil.

Effect of certain dietary oils on bile-acid secretion and serum-cholesterol.

Lewis, B. *Lancet 7030*, 1090–2 (1958). Bile-acid excretion was studied during

the administration of various types of fat, to 3 patients with complete bile fistulae. Sunflower-seed oil (by mouth) and cotton-seed oil (intravenously), which are both highly unsatd., produced a remarkable increase in the rate of cholic-acid secretion, which preceded the fall in serum-cholesterol. On the other hand, a satd. fat (hydrogenated coconut oil) did not affect the bile-acid output but raised the serum-cholesterol. These findings support the hypothesis that the mechanism by which the serum-cholesterol is reduced by certain vegetable oils involves accelerated catabolism of cholesterol to cholic acid.

Mechanism of serum cholesterol lowering by seed fats.

Nutrition Revs. 16, 131–2 (1958).

It is hypothesized that the effect of the unsatd. fat (sunflower seed oil) on the serum cholesterol levels is due to a promotion of sterol catabolism and excretion, particularly in the form of bile acids.

Modifying the fatty acid content of the diet.

STEFANIK, P. A. AND TRULSON, M. F. (Dept. of Nutrition, School of Public Health, Harvard Univ., Boston). *J. Am. Dietetic Assoc., 34*, 591–5 (1958).

Diets modified in proportions of fatty acids for individuals with coronary artery disease are being prescribed by physicians. Information concerning the fatty acid compn. of foods is available. The amt. of polyunsatd. fatty acids in the normal American diet and the distribution of fatty acids in our diet is noted. The prepn. of menus to meet prescriptions for diets low in satd. fatty acids and high in polyunsatd. fatty acids is discussed.

Digestibility of individual fatty acids in the rat.

CARROLL, K. K. (Univ. of Western Ontario, London, Can.). *J. Nutrition 64*, 399–408 (1958).

The digestibility of straight-chain satd. fatty acids from C_4 to C_{22} and of monounsatd. fatty acids from C_{16} to C_{24} has been measured in the rat. Short-chain satd. fatty acids up to C_{10} were completely digested. From C_{10} to C_{18} the digestibility decreased progressively and very small amts. of the C_{18} and higher fatty acids were absorbed. These results do not support the concept of an inverse relationship between the digestibility of fatty acids and their melting points.

Significance of the 'protein-sparing' effect of dextrin.

SPIVEY, H. E., KATAYAMA, M. C., YOSIDA, M. AND HARPER, A. E. (Dept. of Biochem., Univ. of Wisconsin, Madison). *Am. J. Physiol. 193*, 479–82 (1958).

Among the hypotheses proposed to explain the greater food intake and rate of gain of young rats fed *ad libitum* on low

Mr. Gene Lane, Utility Operator, at the Central Soya Co., Inc., Chattanooga, Tenn. plant, operates 36 Merchen Scale Feeders that blend feed ingredients to 1% accuracy.

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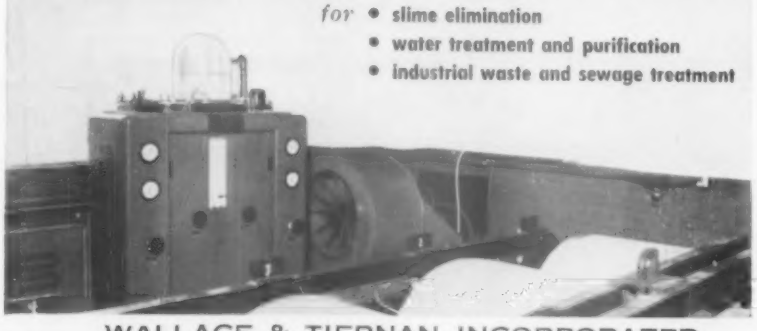

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protein diets in which dextrin or corn starch has been substituted for sucrose are: a) increased intestinal synthesis of essential amino acids; b) improved digestion and absorption of protein owing to slower passage of diets; c) reduced destruction of amino acids in the animal body. The results of nitrogen balance and feeding expts. indicate that improvement in the efficiency of protein utilization when dextrin is substituted for sucrose is too small for any of the above hypotheses to be valid.

The influence of carbohydrate on the utilization of rations containing soybean alpha protein.

REGISTER, U. D. AND PETERSON, E. W. (Coll. of Med. Evangelists, Loma Linda, Calif.). *J. Nutrition 64*, 483–91 (1958).

The influence of carbohydrate upon the growth of rats fed casein and soybean alpha protein rations at levels from 12.5 to 25% has been studied. At the protein levels studied, alpha protein rations with starch supported better growth of rats than those with sucrose. Increased protein efficiency ratios were noted with unheated alpha protein when sucrose was replaced by starch. Differences in rate of release of amino acids from protein, time of passage through the intestinal tract, and altered intestinal flora have been discussed as possible mechanisms.

Action of citrate and oxalacetate on dietary and diabetic ketosis.

FASELLA, P., BAGLIONI, C., TURANO, C. AND SILIPRANDI, N. (Inst. of Biol. Chem., Univ. of Camerino, Italy). *Lancet 7031*, 1097 (1958).

The results show that dietary ketonuria is practically abolished by intraperitoneal injection of either citrate or oxalacetate. Diabetic ketosis, on the other hand, is not significantly influenced either by citrate or by oxalacetate injected intravenously. Diabetic ketosis may not be attributable, as dietary ketosis is, to a deficiency of oxalacetate or of citrate but rather to a disturbance in the Krebs cycle.

The action of insulin.

LEVINE, R. AND GOLDSTEIN, M. S. *Sci. American 198*, 99–106 (1958).

Recent studies have shown that insulin regulates the transport system which allows glucose to enter body cells.

Factors affecting iron absorption.

Nutrition Revs. 16, 113–14 (1958).

Evidence is presented to indicate that iron is converted to hemoglobin more efficiently when given with ascorbic acid and vitamin E.

Calcium metabolism in rats.

Nutrition Revs. 16, 148–9 (1958).

Vitamin D appears to act in conjunction with an endogenous factor in increasing the efficiency of uptake of calcium from the gut at least in those cases where calcium is especially required by the skeleton. The endogenous factor seems to be increased in concn. by calcium deficiency but is incapable of increasing absorption in the absence of vitamin D.

Toxicology

Evaluation of the Suessenguth-Kline test for trichinosis.

SUESSENGUTH, H., BAUER, A. H. AND GREENLEE, A. M. *Public Health Rep. 72*, 939–42 (1957).

Because of frequent difficulty in clin. and lab. diagnosis of trichinosis, there is need for a simple, rapid, and reliable diagnostic test for the disease. The Suessenguth-Kline flocculation slide test for trichinosis is simple and rapid. An antigen emulsion made of cholesterol crystals coated with an alk. ext. of lyophilized trichinae larvae is mixed on a slide with the serum to be tested and rotated for 4 min. The result is read microscopically by the degree of flocculation of the coated crystals. The reproducibility of the flocculation slide test was shown by the 97.1% complete agreement and 1.1% partial agreement of the results obtained in 2 labs. where dupliecate tests were performed on 1,216 serum specimens.

ENGINEERING RESEARCH

Bonding of teflon.

NELSON, E. R., KILDUFF, T. J. AND BENDERLY, A. A. (Diamond Ordnance Fuze Labs., Washington, D. C.). *Ind. Eng. Chem. 50*, 329–30 (1958).

A method of chemically treating teflon surfaces so they can be bonded to metal with epoxy resins.

FOOD AND FOOD TECHNOLOGY

Beverages

For beverage clarity—PVP.

ANON. *Food Eng. 30*, 104–5 (June 1958).

PVP (polyvinylpyrrolodone) now has Federal approval for use as a clarifying agent in beer and wines. It also shows considerable promise as an effective precipitant in fruit jellies, juices and vinegars and also in coffee and tea. This is offered by General Aniline as "Polyclar."

Cereals and Grains

Improving the nutritional value of barley.

Nutrition Revs. 16, 108–9 (1958).

Barley has always been considered to be inferior in nutritional value in animal feeding as compared with corn or wheat, the reason being its high fiber content and poor digestibility of its carbohydrate. It has been found that mixing coarsely ground pearled barley with equal quantities of tap water at 40° C. and allowing it to stand at room temp. for 8 hours greatly increased its nutritive value making it equal to or superior to corn for poultry. Similar increased nutritive value was obtained by feeding it with mixts. of carbohydrate splitting enzymes, namely Takadiastase and Clarase.

Coffee and Coffee Products

Coffee and low blood pressure.

SCHWEISHEIMER, W. *Coffee and Tea Ind. 81*, 48; 67 (June 1958).

The effect of coffee on low blood pressure is discussed in the light of recent research. Coffee increases blood pressure by a few points thus counteracting fatigue, weakness, depression and other unpleasant symptoms assocd. with hypotension.

The action of caffeine on conditioned reflex reactions of rats on an experimental derangement of the nervous system.

MATTHIES, H. AND ERDMANN, D. (Humboldt Univ., Berlin, Ger.). *Pharmazie 12*, 561–7 (1957).

The action of caffeine (I) in 0.5 and 1.0 mg./150 g. doses in young white rats was studied in altering positively or negatively conditioned reflexes; the food-stimulation movement method was used. A shortening of the reaction time to the optical (light) and acoustic (bell, buzzer) conditioned stimuli was produced by I. Also, more accurate differentiation, with fewer erring reactions occurred when I was administered.

Growth inhibition of micro-organisms by coffee.

JOHAR, D. S., NATARAJAN, C. P. AND RAO, T. N. (Central Food Technol. Research Inst., Mysore). *Food Sci. (India) 7*, 29–31 (1958).

The growth of yeasts is not inhibited by coffee, but the growth of bacteria in general is suppressed by coffee and by the vapors from roasted coffee. The rods and cocci in coffee treated cultures were thinner and showed a greater tendency for chain formation.

Eggs

A comparison of selective media for the isolation of Salmonella from commercial egg white solids.

WELLS, F., BERQUIST, D. AND FORSYTHE, R. H. (Central Labs., Henningsen, Inc., Springfield, Mo.). *Appl. Microbiol. 6*, 198–201 (1958).

Two recently developed enrichment media of Osborne and Stokes for the iso-

lation of *Salmonella* from egg products were compared with the currently used selenite F broth in analysis of com. egg white solids. Larger nos. of *Salmonella* were recovered from egg white solids, a greater percentage of the samples was pos., a wider variety of serological types of *Salmonella* was isolated with the new enrichment media than was obtained with selenite F broth.

Fats and Oils

Composition and control of potato chip frying oils in continuing commercial use.

MELNICK, D., LUCKMANN, F. H. AND GOODING, C. M. (Research Labs., The Best Foods Inc., Bayonne, N. J.) *J. Am. Oil Chemists' Soc. 35*, 271–7 (1958).

The oils in use on a continuing com. basis in the production of potato chips on a nation-wide scale are found to be free of thermal polymers. This conclusion is supported by the similarity in phys. properties and in chem. compn. between the fresh and heated oil in any one operation. Based upon statistical quality control considerations, the oils employed in the survey of the potato chip industry have been characterized by having a free fatty acid value of no greater than 0.60% and a decrease in iodine value of no greater than 3.0% in 95% of the operations. These control limits characterize the oils, which, on test, have led to the generalization about the absence of thermal polymers in com. potato chip frying oils.

Meat and Poultry

Effects of package type, irradiation, and treatment with aureomycin on redness of vacuum-packaged beef cuts.

DEAN, R. W. AND BALL, C. O. (Dept. of Food Sci., Rutgers Univ., New Brunswick, N. J.). *J. Agr. Food Chem. 6*, 468–71 (1958).

Redness of fresh beef samples, vacuum-packaged in cans and in film packages, was measured. Samples in cans with small head space had better red color than those in any film-type package. Of the film materials, a coated polyethylene gave the best red-color preservation. Aureomycin treatment of samples prior to packaging was detrimental to red-color retention. Irradiation at a 500,000-rep. level was detrimental to the red color of samples in cans or film packages.

The significant advances of the past fifty years in poultry nutrition.

NORRIS, L. C. (Cornell Univ., Ithaca, N. Y.) *Poultry Sci. 37*, 256–74 (1958).

This review is limited to a consideration of the findings which have had the greatest impact on the poultry industry. In adapting the chick to controlled experimentation under lab. conditions, it was possible to discover the causes of leg weakness in chicks, nutritional roup or xerophthalmia, nutritional leg paralysis, perosis and encephalomalacia and some of the causes of the field hemorrhagic syndrome. The soln. of many of these problems later led to the developments on antibiotics, high energy rations and Calorie-protein relationships, and to the detn. of the requirements of poultry for the indispensable amino acids.

Milk and Milk Products

The nature of changes suffered by milk during technical drying. I. The alimentary liver necrosis of the rat.

FINK, H. AND BRENNER, G. (Univ. Cologne, Ger.). *Z. Physiol. Chem. 309*, 226–7 (1958); *Chem. Abstr. 52*, 8405 h (1958).

The liver necrosis of rats caused by feeding dried skim milk in a proportion 1:10 is not observed when the milk content is increased to 1:5. This excludes the possibility of a toxic substance forming during the drying process. It is probable that partial destruction of essential amino acids, especially S-contg. acids, results in insufficient quantities in the low milk diet and, thus, causes liver necrosis.

Taste Testing

Influence of salt deficiency on taste sensitivity in human subjects.

YENSEN, R. (Psychol. Lab., Univ. of Cambridge, Engl.). *Nature 181*, 1473–5 (1958).

Changes in taste sensitivity were studied in 2 human subjects previously rendered deficient in salt. The results indicated that during periods of salt deficiency, taste sensitivity for salt definitely increased while sensitivity to sweet, sour and bitter solns. showed no such changes.

Miscellaneous

Up-to-date sanitation processes.

DIXON, W. J. *Canner and Freezer 126*, 18–20 (June 1958).

Discusses several present day methods of sanitation and cleaning especially adaptable to food packing plants. In plant chlorination, acid treatment, recirculation and permanent installation of automatic systems are reviewed.

The significance of marine microbiology.

WOOD, E. J. F. (Div. of Fisheries and Oceanog., Cronulla, Australia). *Bacteriol. Revs. 22*, 1–19 (1958).

A brief account of the more recent studies on the activity of marine microorganisms, their ecology, and their possible economic and geobiological roles. This review includes photosynthetic as well as nonphotosynthetic microorganisms.

Nutrition and metabolism of marine bacteria. VII. Growth response of a marine Flavobacterium to surface active agents and nucleotides.

MCLEOD, R. A., HOGENKAMP, H. AND ONOFREY, E. (Technol. Sta., Vancouver, Can.). *J. Bacteriol. 75*, 460–5 (1958).

A marine organism of the genus *Flavobacterium* which grew very slowly in a chemically defined medium unless yeast ext. or other natural materials were added, responded almost as well to a combination of a surface active agent and 3 nucleotides as to yeast ext. It was concluded that the surface active compds. promoted growth because of their surface active properties rather than for any capacity to serve either as precursors of cell lipids or as sources of fatty acids.

The absorption by immature and adult rats of amino acids from raw and autoclaved fresh pork.

WHEELER, P. AND MORGAN, A. F. (Dept. of Nutrition and Home Econ., Univ. of California, Berkeley). *J. Nutrition 64*, 137–50 (1958).

Fifteen amino acids have been detd. in plasma of portal blood taken from immature male and from adult male and female rats at various time intervals after feeding them raw or severely autoclaved fresh pork. Rats fed the raw pork exhibited a prompt increase of free amino acids in plasma from portal blood. Both young and adult rats fed severely autoclaved pork showed much smaller increases. The results are interpreted as supporting the theory that decreases in biol. value caused by overheating proteins are at least in part due to failure of digestive enzymes to hydrolyze the overheated proteins so as to make available simultaneously to the animal an assortment of amino acids favorable to good growth or maintenance.

Coronary-artery disease.

ANON. *Lancet 7021*, 625–7 (1958).

There is so far no satisfactory evidence that the lowering of serum-cholesterol levels, either by diet or by other means, reduces the liability to myocardial infarction; and until such evidence is obtained there is no clear case for drastic measures, dietetic or otherwise, to reduce cholesterol levels. At present the evidence that we suffer from wide-spread partial deficiency of essential fatty acids, and that this contributes to coronary-artery disease, is no more than suggestive. It is best to await new knowledge

before pressing any public-health measures; though the need for investigation is clear enough to be urgent.

Gelatin

Growth promoting activity of gelatin.

Nutrition Revs. 16, 111–12 (1958).

Work is reviewed on growth-promoting activity of gelatin in chicks fed diets contg. a synthetic mixt. of amino acids. This activity was preserved in hydrolyzates and in certain fractions consistent with the hypothesis that it resides partly or largely in an unidentified weakly basic compd. not an amino acid.

PACKAGING

Two plastics gain ease-of-use, new markets.

ARNE, F. *Chem. Eng. 65*, 64–5 (May 5, 1958).

Eastman Chemical Products, Inc. has developed a new low melt polyethylene called Epolene C which can be handled much like a moderate to high melting wax. It is suggested that paper coaters and converters should use conventional wax coating machines for polyethylene laminations instead of special extrusion equipment by using this new material.

Polyethylene wax coatings.

PEACOCK, G. S., MCKNIGHT, W. H. AND AUSTIN, J. M. (Mellon Inst. of Ind. Research, Pittsburgh, Penna.). *Modern Packaging 31*, 137–42 (1958).

Very soft, low density polyethylenes combined with paraffin wax, showed tensile strengths greater than either alone. Water-vapor-permeability studies of coated papers showed lower permeability rates, where the polyethylene-modified coatings were creased, indicating more strength and flexibility due to the polymer.

PERSONNEL

For outstanding activity and significant contributions in the field of technology and research on candy, **Mr. Horace B. Cosler** was awarded the coveted Stroud Jordan medal and scroll at the National Meeting of the American Association of Candy Technologists on July 7th in San Francisco. Cosler, a graduate of Purdue University, served in the Navy in World War I as an ensign. His career in the candy industry started in 1920 as a chemist for the National Candy

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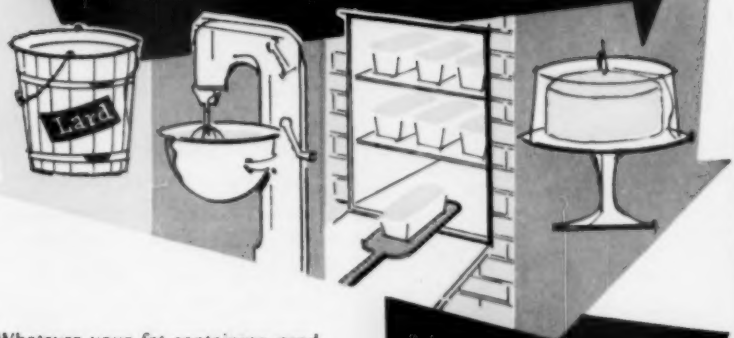

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Company; he became Vice-President in charge of this firm's two Chicago factory operations immediately after World War II.

In the Korean crisis, Mr. Cosler joined the Quartermaster Food and Container Institute for the Armed Forces. Under his direction, research and development work on confections has resulted in producing an assortment of candy bars meeting the rigid ration requirements of the Armed Forces.

Left. Mr. Norman W. Kempf, Manager of Chocolate Development, Walter Baker Chocolate Division, General Foods Corporation, presenting the 8th annual Stroud Jordan award to Horace B. Cosler, U. S. Quartermaster Food and Container Institute.

Mr. Bernard Heath, of the Southern Regional Section Australia and a prominent Melbourne Consulting Chemist and Food Technologist, has been appointed "Controller of Food Standards" Jamaica. Mr. Heath will become Chairman of the Food Standards Committee and will also administrate the Division of Processed Foods. **Mr. Kurt Zentner** also of the Southern Regional Section Australia will be acting Senior partner in the firm of Bernard Heath and Associates during Mr. Heath's absence in Jamaica.

Dr. William F. Hampton has been named director of research and technical development for Ocean Spray cranberry products, it has been announced by Ambrose E. Stevens, general manager and executive vice president of National Cranberry Association, Hanson, Mass. Dr. Hampton has recently returned from Rome, Italy where he served for 3 years on the staff of the Food & Agriculture Organization of the United Nations.

The retirement of **H. C. "Dutch" Diehl** as Director of the Refrigeration Research Foundation has been announced by Garth A. Shoemaker, president. **Dr. Walter A. Maclinn,** Chairman of the Department of Food Science at Rutgers University, has accepted the position from which Dr. Diehl has retired and will assume his duties as head of TRRF on September 1. Dr. Maclinn has a broad background of academic and military service and industry experience. He is a graduate of the University of Massachusetts, having received his doctorate in 1938. During World War II he was Executive Officer and Assistant Director of the Food and Container Research Institute for the Armed Services in Chicago, and he was separated from the service with the rank of Major. He joined Rutgers University in 1946 and initiated a program of research and teaching in the field of food science and technology. Under his leadership and guidance the department has achieved an eminent reputation. "Dutch" Diehl's many friends and associates throughout the nation and overseas wish him well in whatever the future holds for him. He has had a distinguished career in food science and contributed in major degree to its advancement.

A. L. Elder

Dr. Albert L. Elder, Director of Research, Corn Products Company, has been selected as one of the nominees for President-Elect of the American Chemical Society. Election will be by mail ballot of the ACS membership in November. Dr. Elder's career in the chemical field includes university teaching and research, a wartime post with primary responsibilty for expediting penicillin production, and, since World War II, the direction of a major industrial research organization. Dr. Elder has been an active participant in the work of IFT, the Research and Development Associates, the National Research Council, and other technical groups.

Dr. George Denton Beal, distinguished scientist, has retired as a Director of Research at Mellon Institute on August 31, after 32 years of service. Dr. Beal has had a notable career in chemical research, pharmaceutical investigation and education, and research management in a number of industrial fields, including textiles, paper, leather, waxes, varnishes, and food chemistry. His nearly 100 publications deal with basic chemistry, agriculture, food preservatives, industrial hygiene, glass containers, scientific standards, and the philosophy of research. He holds patents in various fields.

A specially designed independent laboratory has been opened in Wilmington, California, by Truesdail to serve food processors and fisheries of the bustling Long Beach-Los Angeles Harbor area. **Dr. Roger W. Truesdail,** president of Truesdail Laboratories, said the new venture will provide faster bacteriological and analytical services to local canners and packers. It also will facilitate certain studies on raw and canned tuna fish, authorized by the U. S. Bureau of Commercial Fisheries under the Saltonstall-Kennedy bill to foster consumption of fisheries products. **F. Leslie Hart** will be in charge.

Mr. Abraham E. Abrahamson, long a professional member of the Institute of Food Technologists, is the recipient of a member award from the Central Atlantic States Association of Food and Drug Officials. This was the first annual award, and it was given on May 28th, 1958 at the annual meeting of this group at Old Point Comfort, Virginia. It was granted "in recognition of his outstanding services to the Association and achievements in his chosen field of food and drug law enforcement."

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R. L. Cheney (right), executive director of Glass Container Manufacturers Institute, pours glass-packed tomato juice for J. C. Feagley (left), chairman of the program committee, and F. N. Dundas (center), first vice-president of GCMI, during the course of a recent three-day meeting attended by some 300 industry executives and their wives.

Two executive changes were recently announced by the directors of Stange Pemberton, Ltd., Canadian subsidiary of the Wm. J. Stange Co. It has been made known that **Frank E. Pemberton**, who has been vice-president for the past five years, has now been appointed president and general manager.

F. E. Pemberton

T. J. Keefe

T. J. Keefe, a member of IFT, who joined the company four years ago and was made assistant general manager a year ago, is now secretary of the firm.

R. E. Bermudez

R. E. Bermudez is now assistant division manager of Kelco Company's central division, headquartered at Chicago. Mr. Bermudez, formerly of New Orleans, has been Kelco representative in the central south for the past five years. In his new post he will promote sales and applications development of algin products to the food, pharmaceutical, cosmetic, textile, and industrial fields.

R. W. Teegarden

Robert W. Teegarden has recently been promoted to general manager of the Union Beach unit of van Ameringen-Haebler, Inc. Mr. Teegarden has served as head of the research department and in various other capacities in production since joining the company in 1932. With the consolidation of chemical manufacturing, engineering, research and development departments in the new plant, Mr. Teegarden's new responsibilities will include the direction and coordination of all operations there.

Guy Byassee

Guy Byassee has been named to the position of division manager of the Bradley & Gilbert division of Standard Packaging Corp. Mr. Byassee, who has 27 years experience in the paper box field, joined the company in 1947 as sales manager. He was vice-president in charge of sales when the company merged with Standard and was named general manager of the division in 1956.

A. S. Dubenchiek

Alexander S. Dubenchiek, who is celebrating his twentieth year in the essential oil industry, has been appointed by Felton Chemical Company, Inc., of Brooklyn, to head their Essential Oil and True Flavor Research Laboratories. Mr. Dubenchiek, a veteran member of the Scientific Committee of the Essential Oil Association of the U. S., has been chairman of several committees engaged in establishing standards for essential oils. He is also a member of the Institute of Food Technologists and the American Chemical Society.

E. W. Nordlinger

Ernest W. Nordlinger, well known assistant editor of Food Processing (Putman Publishing Co.) has joined the industrial advertising agency staff of Roy Zeff & Associates, Inc., Chicago, as vice-president and account executive, where he will head an expanded department handling food supplier and equipment manufacturer advertising and publicity programs. Mr. Nordlinger's long experience on the editorial side of the food industry covers more than a 15-year span, during which he has travelled extensively, observing and reporting on many new food plant processes, food packaging and marketing developments.

A graduate of Purdue University with a degree in Horticulture, he started his career as editor of the Purdue daily and managing editor of the Purdue Agriculturist. His other editorial positions include Crops and Associate Editor of Food Packer magazine and editor of the Isker-Maclinn revision of Campbell's Book on Canning, Pickling and Preserving. Mr. Nordlinger is a national councilor of the Institute of Food Technologists and member of the American Association of Candy Technologists, American Society for Horticultural Science and American Phytopathological Society.

MEMORANDA

A Southeastern conference on Better Foods for Better Nutrition has been scheduled at the University of Georgia, Athens, for March 4-6, 1959. Professional workers in

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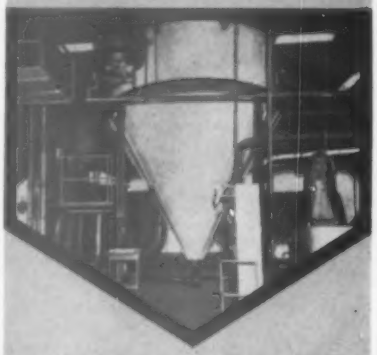

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Attending the fourth annual Food Forum at the Foxboro Co. were, seated left to right, C. L. Taylor, Keebler Biscuit Co.; N. Cole, General Foods Corp.; E. Lombardi, General Foods Corp.; C. B. Smith, Ralston Purina Co.; K. Wendt, Miller Brewing Co.; E. G. Clark, Savannah Sugar Refining Corp.; N. Rosenberg, Refined Syrups and Sugars, Inc.; R. J. Herring, Savannah Sugar Refining Corp.; R. G. Burton, Campbell Soup Co. Standing, left to right, are J. B. Wallace, The Borden Food Products Co.; J. B. Latzer, Pet Milk Co.; W. S. Young, manager of Food Industries division Foxboro; R. A. Lampi, Food Industries division; and M. B. Hall, educational consultant for the Foxboro Co., whose discussion of basic automatic control principles keynoted the forum.

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